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THE ASSOCIATION OF IDEAS.

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THE manner in which trains of imagery and consideration follow each other through our thinking, the restless flight of one idea before the next, the transitions our minds make between things wide as the poles asunder, transitions which at first sight startle us by their abruptness, but which, when scrutinized closely, often reveal intermediating links of thought of perfect naturalness and propriety—all this magical, imponderable streaming has from time immemorial excited the admiration of every living man whose attention happened to be caught by its omnipresent mystery. And it has furthermore challenged the race of philosophers to try to banish something of the mystery by formulating the process in somewhat simpler terms.

Two great philosophic efforts to this end have been made. The one is called the associationist philosophy of England, the other the Herbartian system of Germany. Professor Bain's books are generally regarded as the most successful expression of the first movement. Volkmann's "Psychology" is perhaps the most finished utterance of the last. These schools differ as to their theoretic basis (the one being ontological and the other phenomenal), but they agree in almost all besides; especially in the attempt to show how all the different kinds of mental activity (such as memory, judgment, reasoning, self-consciousness, desire, etc., etc., which were formerly classed as distinct and original "faculties") may be explained as *resultants* of the manner in which, by the working of two or three simple elementary laws of revival between images, these latter are grouped into certain characteristic forms.

In fact, the easiest way of describing the entire industry of these

schools would be to say that they seek to explain the forms of consciousness by means of its materials.

Now, to another class of minds any such attempt seems so preposterously absurd that they pour out the child with the bath, and disdain even a modest ambition which should content itself with tracing out in the jungle of the mind a few of the trails by which its *materials* are brought together. As this article is born of the latter ambition, and as its author thinks he has succeeded in making the trails broader and smoother than previous writers have left them, it behooves him to defend himself and his purpose by a few preliminary words addressed to this class of critics. They are recruited mainly from the school of Hegel, but we find even as fertile and acute a writer as Lotze sharing their prejudices and negations in this respect.

The intuition they start from is that thought is not a sand-heap of juxtaposed images with associating links outside of them and between them. It is a unitary *continuum* of which the items, and the logical relations between the items, form alike integral parts, equally imbedded, equally essential, equally interdependent. *Any* relation may carry us from one item to another, and according as we follow one or the other relation we shall traverse the field of thought in this way or in that, have one train of images or its opposite. But all the relations are *logical*, are relations of *reason*. A thing may suggest its like, or its opposite, its genus or its species, its cause or its effect, its means or its purpose, its habitual neighbors in space or in time, its possibilities or its impossibilities, its changes or its resistance to change—in short, it *may* call up every consideration to which it can have a possible logical relevancy, and call up each in its turn. And the only summary formula that can be applied to all these infinite possibilities of transition is that, as transitions of Thought, they are all alike *acts of Reason*. This monotonous appeal to "Thought" with a capital T and Reason with a capital R is apt to irritate the ear of him bent on analysis, very much as the stereotyped "Allah is great" of the Mussulman irritates the ear of the scientific traveler. It is true enough, but sterile. And, when it interdicts discrimination and the search for secondary causes, it performs as obstructive a function as that of our dear old friend the dog in the manger.

For these so-called "transitions of Reason" are far from being all alike reasonable. If pure Thought runs all our trains, why should she run some so fast and some so slow, some through dull flats and some through gorgeous scenery, some to mountain-heights and jeweled mines, others through dismal swamps and darkness?—and run some off the track altogether, and into the wilderness of lunacy? Why do we spend years straining after a certain scientific or practical problem, but all in vain—Thought refusing to evoke the solution we desire? And why, some day, walking in the street with our attention miles away from that quest, does the answer saunter into our minds as care-

lessly as if it had never been called for—suggested, possibly, by the flowers on the bonnet of the lady in front of us, or possibly by nothing that we can discover? If Reason can give us relief then, why did she not do so earlier?

The truth must be admitted that pure Thought works under conditions imposed *ab extra*. The great law of habit itself—that twenty experiences make us recall a thing better than one, that long indulgence in error makes right thinking almost impossible—seems to have no essential foundation in reason. The business of pure Thought is with Truth—the number of experiences ought to have nothing to do with her hold of it; and she ought by right to be able to hug it all the closer, after years wasted out of its presence. Such arrangements seem quite fantastic and arbitrary, but nevertheless are part of the very bone and marrow of our minds. Reason is only one out of a thousand possibilities in the thinking of each of us. Who can count all the silly fancies, the grotesque suppositions, the utterly irrelevant reflections he makes in the course of a day? Who can swear that his prejudices and irrational beliefs constitute a less bulky part of his mental furniture than his clarified opinions? It is true that a presiding arbiter seems to sit aloft in the mind, and emphasize the better suggestions into permanence, while it ends by dropping out and leaving unrecorded the confusion. But this is all the difference. The *mode of genesis* of the worthy and the worthless seems the same. The laws of our actual thinking, of the *cogitatum*, must account alike for the bad and the good materials on which the arbiter has to decide, for wisdom and for folly. The laws of the arbiter, of the *cogitandum*, of what we *ought* to think, are to the former as the laws of ethics are to those of history. Who but an Hegelian historian ever pretended that reason in action was *per se* a sufficient explanation of the political changes in Europe?

There are, then, mechanical conditions on which Thought depends, and which, to say the least, determine the order in which is presented the content or material for her comparisons, selections, and decisions. It is a suggestive fact that Locke, and many more recent Continental psychologists, have found themselves obliged to invoke a mechanical process to account for the aberrations of Thought, the obstructive prepossessions, the frustrations of Reason. This they found in the law of habit, or what we now call Association by Contiguity. But it never occurred to these writers that a process which could go the length of actually producing some ideas and sequences in the mind might safely be trusted to produce others too; and that those habitual associations which further thought may come from the same mechanical source as those which hinder it. Hartley accordingly suggested habit as an all-sufficient explanation, but failed to dispose of the difficulty which comes in when we notice that in the *highest* flights of Reason habit does not seem the link between one item and the next. Rather

are the transitions of genius distinguished by their express defiance of all that is habitual.

This led to the erection of other laws to supply the gaps in explanation left by the law of habit alone. No sensible man now considers the habit-philosophy of Hartley, Priestley, and James Mill to be adequate to its task. Professor Bain, reverting to Hume's standpoint, supplements the law of Contiguity by that of Similarity, and, in a subordinate degree, by that of Contrast. *All* the materials of thought, without conception, are in his psychology pushed or drawn before the footlights of consciousness by the working of these laws and by them alone.

Mr. Hodgson, ablest of recent (if not of all) English philosophers, supplements Bain's laws by an important principle, that of Interest.

And every one before whose consciousness, when falling asleep, trains of faces and other disconnected images are wont to pass, and who, moreover, after his attention has once been called to the subject, surprises vestiges of the same process at work during his waking hours, in the form of a sort of meteoric shower of random images, visual or verbal, which cross the main current of thought, but are so faint that they ordinarily arrest no attention and are forthwith forgotten * —every such person, I say, will plead for the admission of a principle of spontaneity or accidental arousal, along with the principles already mentioned.

In the pages that follow I accept all these laws save that of contrast; and that I do not reject, but simply ignore and disregard on the present occasion. I try to show how they all may follow from certain variations in a fundamental process of activity in the brain. In particular I reduce Contiguous and Similar Associations to one, by exhibiting their most pronounced forms as mere extremes of a common mode. But the reader is requested to remember that in thus trying to explain, by laws of matter, what ideas shall be presented to consciousness at any moment, I expressly repudiate the pretension to explain the form of consciousness itself. Consciousness, as I understand it, is always in the midst of the present aware of the past as that from which the present came; and, out of the materials which the present furnishes, she is always comparing one part with another, to select that which most fits her ends. These peculiarities of consciousness were referred to above, when it was spoken of as a "presiding arbiter." I am wholly unable to picture this strange discriminating industry, this bringing of things together in order to keep them apart, this setting of ends and choosing from equal possibilities, in terms of any physical process whatever. The laws of association to be treated of here might, for aught we can see, be true in a creature wholly devoid of memory or comparison. Each of his ideas would vanish in the act of awakening its successor; his mind (if such it

* See Maury's classic work, "Le Sommeil et les Rêves."

could be called) would be shut up to the punctiform instant; he would obey, without noticing, the current which swept him on; drift to his conclusions, but never know why; and act upon the suggestions of experience with a fatality which would be inwardly all the blinder in proportion as it was the more rational to outward semblance. I simply *assume* for his benefit the possession of a consciousness. I *beg* that much from the reader's liberality; and limit my ambition to showing (the consciousness being granted) with what objects it is at any given moment most likely to be filled.

The laws of motor habit in the lower centers of the nervous system are disputed by no one. A series of movements repeated in a certain order tend to unroll themselves with peculiar ease in that order for ever afterward. Number one awakens number two, and that awakens number three, and so on, till the last is produced. A habit of this kind once become inveterate, like the manipulations of certain trades, the balancings of the body in standing or walking, the varying pressure of the legs in response to the swayings of a horse's gait, may go on automatically while the mind concerns itself with far other affairs. And so it is with thoughts. Not only poems, but the multiplication-table, Greek verbs, and formulas of gibberish like "*ana, mana, mona, mike,*" etc., cohere in the self-same order in which they have once been learned. If we have blundered once in a certain place, we are prone to repeat the mistake again. The higher and the lower nerve-centers, then, are subject to one and the same law; and the reason of the law must be in both cases the same. The fact that there are isolated tracts of conduction in all the centers, and that as we pass from below upward the different centers have in the main different characteristic functions, leads to the notion that each function, ideational or motor, is dependent on a certain tract localized somewhere, which tract when once excited may propagate the excitement to other outlying tracts. The reason for the law of habit would, then, seem to be that the propagation occurs easiest through those tracts of conduction which have been already most in use. Descartes and Locke hit upon this explanation, which modern science has not yet succeeded in improving. "Custom," says Locke, "settles habits of thinking in the understanding as well as of determining in the will, and of motions in the body; all which seem to be but trains of motion in the *animal spirits* (by this Locke meant identically what we understand by the words *neural process*), which, once set agoing, continue in the same steps they have been used to, which by often treading are worn into a smooth path, and the motion in it becomes easy and as it were natural."

Let us, then, *assume* as the basis of all our subsequent reasoning the following law: *When two brain tracts or processes have occurred together or in immediate succession, any one of them, on reoccurring, tends to propagate its excitement into the other.*

Now, as a matter of fact, things in the brain are much less simple

than this. Every elementary tract or process has found itself at different times excited in conjunction with *many* other tracts or processes, and this by unavoidable outward causes. Which of these others it shall awaken now becomes a problem. Shall *b* or *c* be aroused next by the present *a*? We must make a further postulate, based, however, on the undeniable fact of *tension* in nerve-tissue, and the summation of excitements, each incomplete or latent in itself, into an open resultant; *b* rather than *c* will awake, if in addition to the vibrating tract *a* some other tract *d* is in a state of sub-excitement, and formerly was excited with *b* alone and not with *a*. In short, we may say:

The amount of activity at any given point in the brain-cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) *to the number of times the excitement of each other point may have coexisted with that of the point in question;* (2) *to the intensity of such excitements; and* (3) *to the absence of any rival locality or process functionally disconnected with the first point, into which the discharges might be diverted.*

Expressing the fundamental law in this most complicated way leads to the greatest ultimate simplification. This will now be seen; but the reader will bear in mind that our limits only allow us to treat of spontaneous trains of thought and ideation, such as occur in reverie or musing. The case of voluntary thinking toward a certain end must be postponed to another opportunity.

Take, to fix our ideas, the two verses from "Locksley Hall":

"I, the heir of all *the ages* in the foremost files of time,"

and—

"For I doubt not through *the ages* one increasing purpose runs."

Why is it that when we recite from memory one of these lines and get as far as *the ages* that portion of the *other* line which follows, and, so to speak, sprouts out of *the ages*, does not also sprout out of our memory, and confuse the sense of our words? Simply because the word that follows *the ages* has its brain-process awakened not simply by the brain-process of *the ages* alone, but by it *plus* the brain-processes of all the words preceding *the ages*. The word *ages* at its moment of strongest activity would, *per se*, indifferently discharge into either "in" or "one." So would the previous words (whose tension is momentarily much less strong than that of *ages*) each of them indifferently discharge into either of a large number of other words with which they have been at different times combined. But when the processes of "So I doubt not through the ages" simultaneously vibrate in the brain, the strongest line of discharge will be that which they all alike tend to take. "One" and not "in" or any other word will be the next to awaken, for its brain-process has previously vibrated in unison not only with that of *ages*, but with that of all those other words whose activity is just dying away.

In case of some one of these preceding words—"heir," for example—having an intensely strong association with some brain-tracts entirely disjoined in experience from the poem of "Locksley Hall"—in case the reciter, for instance, was tremulously awaiting the opening of a will which might make him a millionaire or leave him penniless—it is probable that the path of discharge through the words of the poem would be suddenly interrupted at the word "heir." His emotional interest in that word would be such that its own special associations would prevail over the combined ones of the other words. He would, as we say, be abruptly reminded of his personal situation, and the poem would lapse altogether from his thoughts.

The writer of these pages has every year to learn the names of a large number of students who sit in alphabetical order in a lecture-room. On meeting one in the street, early in the year, the face hardly ever recalls the name, but it may recall the place of its owner in the lecture-room, his neighbors' faces, and consequently his general alphabetical position; and then, usually as the common associate of all these combined data, the student's name surges up in my mind.

A father wishes to show to some guests the progress of his rather dull child in Kindergarten instruction. Holding the knife upright on the table, he says, "What do you call that, my boy?" "I calls it a *knife*, I does," is the sturdy reply, from which the child can not be induced to swerve by any alteration in the form of question, until the father, recollecting that in the Kindergarten a pencil was used, and not a knife, draws a long one from his pocket, holds it in the same way, and then gets the wished-for answer, "I calls it *vertical*." All the concomitants of the Kindergarten experience had to recombine their effect before the word "vertical" could be reawakened.

Professor Bain, in his chapters on Compound Association, has treated in a minute and exhaustive way of this type of mental sequence, and what he has done so well need not be here repeated.

The ideal working of the law of compound association, were it unmodified by any extraneous influence, would be such as to keep the mind in a perpetual treadmill of concrete reminiscences from which no detail could be omitted. Suppose, for example, we begin by thinking of a certain dinner-party. The only thing which all the components of the dinner-party could combine to recall would be the first concrete occurrence which ensued upon it. All the details of this occurrence could in turn only combine to awaken the next following occurrence and so on. If *a*, *b*, *c*, *d*, *e*, for instance, be the elementary nerve-tracts excited by the last act of the dinner-party, call this act A, and *l*, *m*, *n*, *o*, *p* be those of walking home through the frosty night, which we may call B, then the thought of A must awaken that of B, because *a*, *b*, *c*, *d*, *e*, will each and all discharge into *l* through the paths by which their original discharge took place. Similarly they will discharge into *m*, *n*, *o*, and *p*, and these latter tracts will each re-

enforce the other's action because, in the experience B, they have already vibrated in unison. The lines in the diagram symbolize the summation of discharges into each of the components of B, and the consequent strength of the combination of influences by which B in its totality is awakened.

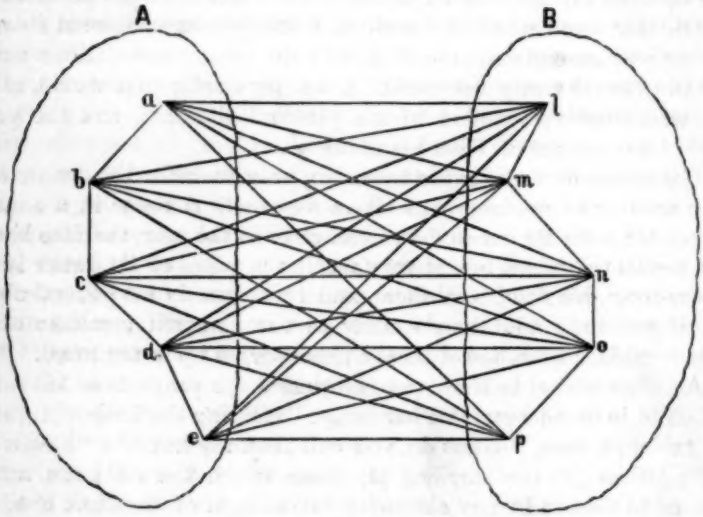

FIG. 1

Hamilton first used the word "redintegration" to designate all association. Such processes as we have just described might in an emphatic sense be termed redintegrations, for they would necessarily lead, if unobstructed, to the reinstatement in thought of the *entire* content of large trains of past experience. From this complete redintegration there could be no escape save through the irruption of some new and strong present impression of the senses or through the excessive tendency of some one of the elementary brain-tracts to discharge independently into an aberrant quarter of the brain. Such was the tendency of the word "heir" in the verse from "Locksley Hall," which was our first example. How such tendencies are constituted, we shall have soon to inquire with some care. Unless they are present, the panorama of the past, once opened, must unroll itself with fatal literality to the end, unless some outward sound, sight, or touch divert the current of thought.

I prefer to discard the word "redintegration" altogether, and to give to this unobstructed process the name of Complete Association by Contiguity. Whether it ever occurs in this absolutely complete form is doubtful. We all immediately recognize, however, that in some minds there is a much greater tendency than in others for the flow of thought to take this form. Those insufferably garrulous old women, those dry

and fanciless beings who spare you no detail, however petty, of the facts they are recounting, and upon the thread of whose narrative all the irrelevant items cluster as pertinaciously as the essential ones, the slaves of literal fact, the stumblers over the smallest abrupt step in thought, are figures known to all of us. Comic literature has made her profit out of them. Juliet's nurse is a classical example. George Eliot's village characters and some of Dickens's minor personages supply excellent instances.

Perhaps as successful a rendering as any of this mental type is the character of Miss Bates in Miss Austen's "Emma." Hear how she redintegrates: "'But where could *you* hear it?' cried Miss Bates. 'Where could you possibly hear it, Mr. Knightley? For it is not five minutes since I received Mrs. Cole's note—no, it can not be more than five—or at least ten—for I had got my bonnet and spencer on, just ready to come out—I was only gone down to speak to Patty again about the pork—Jane was standing in the passage—were not you, Jane?—for my mother was so afraid that we had not any salting-pan large enough. So I said I would go down and see, and Jane said: "Shall I go down instead? for I think you have a little cold, and Patty has been washing the kitchen." "Oh, my dear," said I—well, and just then came the note. A Miss Hawkins—that's all I know—a Miss Hawkins, of Bath. But, Mr. Knightley, how could you possibly have heard it? for the very moment Mr. Cole told Mrs. Cole of it, she sat down and wrote to me. A Miss Hawkins—'"

But in every one of us there are moments when this complete reproduction of all the items of a past experience occurs. What are those moments? They are moments of emotional recall of the past as something which once was, but is gone for ever—moments, the interest of which consists in the feeling that our self was once other than it now is. When this is the case, any detail, however minute, which will make the past picture more complete, will also have its effect in swelling that total contrast between *now* and *then* which forms the central interest of our contemplation.

This case helps us to understand why it is that the ordinary spontaneous flow of our ideas does not follow the law of "complete" Association by Contiguity. In no revival of a past experience are all the items of our thought equally and impartially operative in determining what the next thought shall be. Always some ingredient is prepotent over the rest. Its special suggestions or associations in this case will often be different from those which it has in common with the whole group of items; and its tendency to awaken these outlying associates will deflect the path of our reverie. Just as in the original sensible experience our attention focalized itself upon a few of the impressions of the scene before us, so here in the reproduced representation of those impressions the same partiality is shown, and some items emphasized above the rest. What these items shall be is, in most cases of sponta-

neous reverie, hard to determine beforehand. In subjective terms we say that the prepotent items are those which appeal most to our *interest.*

Expressed in brain-terms, the law of interest will be: *some one brain-process is always prepotent above its concomitants in arousing action elsewhere.*

"Two processes," says Mr. Hodgson,* "are constantly going on in redintegration. The one a process of corrosion, melting, decay; the other a process of renewing, arising, becoming. . . . No object of representation remains long before consciousness in the same state, but fades, decays, and becomes indistinct. Those parts of the object, however, which possess an interest, that is, those which are attended by a representation of pleasure or pain, resist this tendency to gradual decay of the whole object. . . . This inequality in the object—some parts, the uninteresting, submitting to decay; others, the interesting parts, resisting it—when it has continued for a certain time, ends in becoming a new object." Only where the interest is diffused equally over all the parts (as in the emotional memory just referred to, where, as all *past,* they all interest us alike) is this law departed from. It will be least obeyed by those minds which have the smallest variety and intensity of interests—those who, by the general flatness and poverty of their æsthetic nature, are kept for ever rotating among the literal sequences of their local and personal history.

Most of us, however, are better organized than this, and our musings pursue an erratic course, swerving continually into a new direction traced out by the shifting play of interest as it irradiates always some partial item in each complex representation that is evoked. Thus it commonly comes about that we find ourselves thinking at two nearly adjacent moments of things separated by the whole diameter of space and time. Not till we carefully recall each step of our cogitation do we see how naturally we came by Hodgson's law to pass from one to the other. Thus, for instance, after looking at my clock just now, I found myself thinking of Senator Bayard's recent resolution about our legal-tender notes. The clock called up the image of the man who had repaired its gong. He suggested the jeweler's shop where I had last seen him; that shop, some shirt-studs which I had bought there; they, the value of gold and its recent decline; the latter, the equal value of greenbacks, and this naturally the question of how long they were to last, and of the Bayard proposition. Each of these images offered various points of interest. Those which formed the turning-points of my thought are easily assigned. The gong was momentarily the most interesting part of the clock, because, from having begun with a beautiful tone, it had become discordant and aroused disappointment and perplexity. But for this, the clock might have suggested the friend who gave it to me, or any one of a thousand circumstances connected with it. The jeweler's shop suggested the studs,

* "Time and Space," p. 266.

because they alone of all its contents were tinged with the egoistic interest of possession. This interest in the studs, their value, made me single out the material as its chief source, etc., to the end. Every reader who will arrest himself at any moment and say, "How came I to be thinking of just this?" will be sure to trace a train of representations linked together by lines of contiguity and points of interest inextricably combined. This is the ordinary process of the association of ideas as it spontaneously goes on in average minds. We may call it Partial or *Mixed Association.*

Another example of it is given by Hobbes in a passage which has been quoted so often as to be classical: "In a discourse of our present civil war, what could seem more impertinent than to ask (as one did) what was the value of a Roman penny? Yet the coherence to me was manifest enough. For the thought of the war introduced the thought of the delivering up the King to his enemies; the thought of that brought in the thought of the delivering up of Christ; and that again the thought of the thirty pence, which was the price of that treason: and thence easily followed that malicious question; and all this in a moment of time; for thought is quick."

Can we determine now when a certain portion of the going thought has, by dint of its interest, become so prepotent as to make its own exclusive associates the dominant features of the coming thought—can we, I say, determine *which* of its own associates shall be evoked? For they are many. As Hodgson says: "The interesting parts of the decaying object are free to combine again with any objects or parts of objects with which at any time they have been combined before. All the former combinations of these parts may come back into consciousness; one must; but which will?" Mr. Hodgson replies: "There can be but one answer: that which has been most *habitually* combined with them before. This new object begins at once to form itself in consciousness, and to group its parts round the part still remaining from the former object; part after part comes out and arranges itself in its old position; but scarcely has the process begun, when the original law of interest begins to operate on this new formation, seizes on the interesting parts and impresses them on the attention to the exclusion of the rest, and the whole process is repeated again with endless variety. I venture to propose this as a complete and true account of the whole process of redintegration."

In restricting the discharge from the interesting item into that channel which is simply most *habitual* in the sense of most frequent, Hodgson's account is assuredly imperfect. An image by no means always revives its most frequent associate, although frequency is certainly one of the most potent determinants of revival. If I abruptly utter the word *swallow*, the reader, if by habit an ornithologist, will think of a bird; if a physiologist or a medical specialist in throat-diseases, he will think of deglutition. If I say *date*, he will, if a fruit-

merchant or an Arabian traveler, think of the produce of the palm; if an habitual student of history, figures with A. D. or B. C. before them will rise in his mind. If I say *bed, bath, morning*, his own daily toilet will be invincibly suggested by the combined names of three of its habitual associates. But frequent lines of transition are often set at naught. The sight of C. Göring's "System der kritischen Philosophie" has most frequently awakened in me thoughts of the opinions therein propounded. The idea of suicide has never been connected with the volumes. But a moment since, as my eye fell upon them, suicide was the thought that flashed into my mind. Why? Because but yesterday I received a letter from Leipsic informing me that this philosopher's recent death by drowning was an act of self-destruction. Thoughts tend, then, to awaken their most recent as well as their most habitual associates. This is a matter of notorious experience, too notorious, in fact, to need illustration. If we have seen our friend this morning, the mention of his name now recalls the circumstances of that interview, rather than any more remote details concerning him. If Shakespeare's plays are mentioned, and we were last night reading "Richard II.," vestiges of that play rather than of "Hamlet" or "Othello" float through our mind. Excitement of peculiar tracts, or peculiar modes of general excitement in the brain leave a sort of tenderness or exalted sensibility behind them which takes days to die away. As long as it lasts, those tracts or those modes are liable to have their activities awakened by causes which at other times might leave them in repose. Hence, *recency* in experience is a prime factor in determining revival in thought.

Vividness in an original experience may also have the same effect as habit or recency in bringing about likelihood of revival. If we have once witnessed an execution, any subsequent conversation or reading about capital punishment will almost certainly suggest images of that particular scene. Thus it is that events lived through only once, and in youth, may come in after-years, by reason of their exciting quality or emotional intensity, to serve as types or instances used by our mind to illustrate any and every occurring topic whose interest is most remotely pertinent to theirs. If a man in his boyhood once talked with Napoleon, any mention of great men or historical events, battles or thrones, or the whirligig of fortune, or islands in the ocean, will be apt to draw to his lips the incidents of that one memorable interview. If the word *tooth* now suddenly appears on the page before the reader's eye, there are fifty chances out of a hundred that, if he gives it time to awaken any image, it will be an image of some operation of dentistry in which he has been the sufferer. Daily he has touched his teeth and masticated with them; this very morning he brushed them, chewed his breakfast and picked them; but the rarer and remoter associations arise more promptly because they were so much more intense.

A fourth factor in tracing the course of reproduction is *congruity in emotional tone* between the reproduced idea and our mood. The same objects do not recall the same associates when we are cheerful as when we are melancholy. Nothing, in fact, is more striking than our utter inability to keep up trains of joyous imagery when we are depressed in spirits. Storm, darkness, war, images of disease, poverty, and perishing afflict unremittingly the imaginations of melancholiacs. And those of sanguine temperament, when their spirits are high, find it equally impossible to give any permanence to evil forebodings or to gloomy thoughts in general. In an instant the train of association dances off to flowers and sunshine, and images of spring and hope. The records of Arctic or African travel perused in one mood awaken no thoughts but those of horror at the malignity of Nature; read at another time they suggest only enthusiastic reflections on the indommitable power and pluck of man. Few novels so overflow with joyous animal spirits as "The Three Guardsmen" of Dumas. Yet it may awaken in the mind of a reader depressed with sea-sickness (as the writer can personally testify) a most dismal and woful consciousness of the cruelty and carnage which heroes like Athos, Porthos, and Aramis make themselves guilty of.

Habit, recency, vividness, and emotional congruity are, then, all reasons why one representation rather than another should be awakened by the interesting portion of a departing thought. We may say with truth that in the majority of cases the coming representation will have been either habitual, recent, or vivid, and will be congruous. If all these qualities unite in any one absent associate, we may predict almost infallibly that that associate of the going thought will form an important ingredient in the coming thought. In spite of the fact, however, that the succession of representations is thus redeemed from perfect indeterminism and limited to a few classes whose characteristic quality is fixed by the nature of our past experience, it must still be confessed that an immense number of terms in the linked chain of our representations fall outside of all assignable rule. To take the instance of the clock given on page 586. Why did the jeweler's shop suggest the shirt-studs rather than a chain which I had bought there more recently, which has cost more, and whose sentimental associations were much more interesting? Both chain and studs had excited brain-tracts simultaneously with the excitement of others by the general aspect of the shop. The only reason why the nerve-stream from the shop-tract switched off into the stud-tract rather than the chain-tract must be that the stud-tract happened at that moment to lie more open, either because of some accidental alteration in its nutrition or because the incipient sub-conscious tensions of the brain as a whole had so distributed their equilibrium that it was more unstable here than in the chain-tract. Any reader's introspection will easily furnish similar instances. It thus remains true that to a certain extent, even in those

forms of ordinary Mixed Association which lie nearest to Pure Association by Contiguity, *which* associate of the interesting item shall emerge must be called largely a matter of accident—accident, that is, for our intelligence. No doubt it is determined by cerebral causes, but they are too subtile and shifting for our analysis.

In Partial or Mixed Association we have all along supposed that the interesting portion of the disappearing thought was of considerable extent, was sufficiently complex to constitute by itself a concrete object. Sir William Hamilton relates that after thinking of Ben Lomond he found himself thinking of the Prussian system of education, and discovered that the links of association were a German gentleman whom he had met on Ben Lomond, Germany, etc. The interesting part of Ben Lomond, the part operative in determining the train of his ideas was the complex image of a particular man. But now let us suppose that that selective agency of interested attention, which may convert in the way we have seen complete contiguous association into partial association—let us suppose that it refines itself still further and accentuates a portion of the passing thought, so small as to be no longer the image of a concrete thing, but only of an abstract quality or property. Let us, moreover, suppose that the part thus accentuated persists in consciousness (or, in cerebral terms, has its brain-process excited) after the other portions of the thought have faded. This small surviving portion will then surround itself with its own associates after the fashion we have already seen, and the relation between the new thought and the faded one will be a *relation of similarity*. The pair of thoughts will form an instance of what is called "Association by Similarity." To make this perfectly plain we must understand exactly what constitutes similarity between two things. The moon is similar to a gas-jet, it is also similar to a foot-ball; but a gas-jet and a foot-ball are not similar to each other. When we affirm the similarity of two things, we should always say *in what respect it obtains*. Moon and gas-jet are similar in respect of luminosity, and nothing else; moon and foot-ball in respect of rotundity, and nothing else. Foot-ball and gas-jet are in no respect similar—that is, they possess no common point, no identical attribute. Objects are really identical with each other in that point with respect to which they are called similar. Similarity is partial identity. When the *same* attribute appears in two phenomena, though it be their only common property, the two phenomena are similar in so far forth. To return now to our associated representations. If the thought of the moon is succeeded by the thought of a foot-ball, and that by the thought of one of Mr. Vanderbilt's railroads, it is because the attribute rotundity in the moon broke away from all the rest and surrounded itself with an entirely new set of companions—elasticity, leathery integument, swift mobility in obedience to human caprice, etc.; and because the last-named attribute in the foot-ball in turn

broke away from its companions, and, itself persisting, surrounded itself with such new attributes as make up the notions of a "railroad king," of a rising and falling stock-market, and the like.

The gradual passage from Complete Contiguous to Similar Associ-

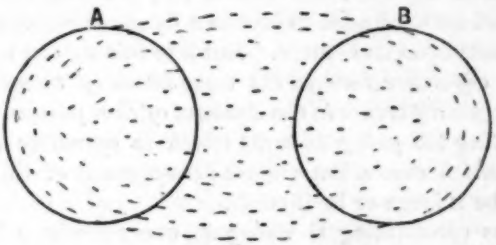

FIG. 2.

ation through what we have called Partial Association may be symbolized by diagrams. Fig. 2 is Pure Contiguous, Fig. 3 is Mixed, and Fig. 4 Similar, Association. A in each is the passing, B the coming thought. In "Contiguous," all parts of A are equally operative in

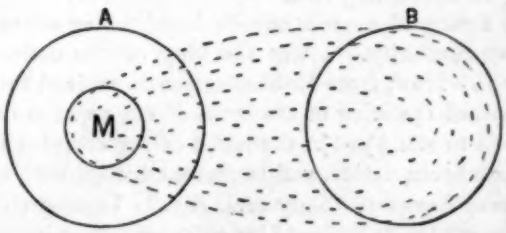

FIG. 3.

calling up B. In "Mixed," most parts of A are inert. The part M alone breaks out and awakens B. In "Similar," the focalized part M is much smaller than in the previous case, and after awakening its

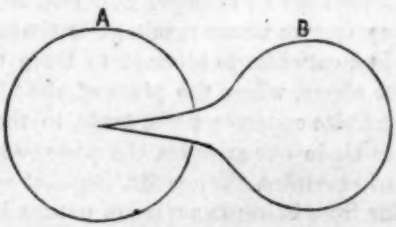

FIG. 4.

new set of associates, instead of fading out itself, it continues persistently active along with them, forming an identical part in the two ideas, and making these, *pro tanto*, resemble each other.

Why a single portion of the passing thought should break out from its concert with the rest and act, as we say, on its own hook, why the other parts should become inert, are mysteries which we can ascertain but not explain. Possibly a minuter insight into the laws of neural action will some day clear the matter up; possibly neural laws will not suffice, and we shall need to invoke a dynamic reaction of the form of consciousness upon its content. But into this we can not enter now.

Thus the difference between the three kinds of association reduces itself to a simple difference in the Amount of that portion of the nerve-tract supporting the going thought which is operative in calling up the thought which comes, but the *modus operandi* of this active part is the same, be it large or be it small.

The items constituting B waken in every instance because their nerve-tracts once were excited continuously with those of A or its operative part. This ultimate physiological law (*supra*, p. 583) is what *runs* the train. The direction of its course and the form of its transitions, whether contiguous or similar, are due to unknown regulative or determinative conditions which accomplish their effect by opening this switch and closing that, setting the engine sometimes at half speed, and coupling or uncoupling cars.

This last figure of speech affords itself an excellent instance of association by similarity. I was thinking of the deflections of the course of ideas. Now, from Hobbes's time downward English writers have been fond of speaking of the *train* of our representations. This word happened to stand out in the midst of my complex thought with peculiarly sharp accentuation, and to surround itself with numerous details of railroad imagery. Only such details became clear, however, as had their nerve-tracts besieged by a double set of influences—those from *train* on the one hand, and those from the *movement of thought* on the other. It may possibly be that the prepotency of the suggestions of the word *train* at this moment were due to the recent excitation of the railroad brain-tract by the instance chosen a few pages back of a railroad king playing foot-ball with the stock-market.

It is apparent from such an example how inextricably complex are all the contributory factors whose resultant is the line of our reverie. It would be folly in most cases to attempt to trace them out. From an instance like the above, where the pivot of the Similar Association was formed by a definite concrete word, *train*, to those where it is so subtile as utterly to elude our analysis, the passage is unbroken. We can form a series of examples. When Mr. Bagehot says that the mind of the savage, so far from being in a state of nature, is *tattooed* all over with monstrous superstitions, the case is very like the one we have just been considering. When Sir James Stephen compares our belief in the uniformity of nature, the congruity of the future with the past, to a man rowing one way and looking another, and steering his boat by keeping her stern in a line with an object behind him, the operative

link becomes harder to dissect out. It becomes a real puzzle when the color pale-blue is said to have feminine, and blood-red masculine affinities. And if I hear a friend describe a certain family as having voices like *blotting-paper*, the image, though immediately felt to be apposite, baffles the utmost powers of analysis. The higher poets all use abrupt epithets, which are alike intimate and remote, and, as Emerson says, sweetly torment us with invitations to their inaccessible homes.

In these latter instances we must suppose that there is an identical portion in the similar ideas and that it is energetically operative, without, however, being sufficiently accentuated in consciousness to stand out *per se*, attract the attention to itself and be abstracted. We can not even by careful search see the bridge over which we passed from the heart of one representation to that of the next. In some brains, however, this mode of transition it extremely common. It would be one of the most important of physiological discoveries could we assign the mechanical or chemical difference which makes the thoughts of one brain cling close to Pure Contiguity while those of another shoot about in all the lawless revelry of Similarity. Why in these latter brains action should tend to focalize itself in small spots, while in the others it fills patiently its broad bed, it seems impossible to guess. Whatever the difference may be, it is what separates the man of genius from the prosaic creature of habit and routine thinking. Professor Bain, more profusely and cogently than any one else, has illustrated the truth that the leading fact in what we call genius in every department of life is a high development of the power of Similar Association. I therefore refer the reader to his work on the "Study of Character," Chapter XV., and to Chapter II., sections 25 to 45, of the portion entitled "Intellect" of his treatise on "The Senses and the Intellect."

Into the study of voluntary trains of thought there is no space to enter. The student will find in Hodgson's "Theory of Practice," vol. i., pp. 394–400, the best account with which I am acquainted. Meanwhile he will no doubt admit that the promise with which this article set out has been fulfilled, and that the processes of spontaneous association have become already a little more intelligible to his mind.

DOLMENS IN JAPAN.

By EDWARD S. MORSE.

THOUGH a large amount of material has been collected and published regarding the megalithic structures of Europe, their classification is in a somewhat unsatisfactory condition.

The misery of the systematist has already made itself apparent in

synonyms for a well-known class of monuments—namely, the dolmens. To make the matter more perplexing, structures of quite a different form, and possibly intended for a different purpose, are called by the same name.

A dolmen, generally speaking, consists of an arrangement of stones, few or many in number, supporting one or more stones in such a way as to inclose a cavity beneath. These supporting stones may form the four walls of a chamber, which may or may not be covered by a mound of earth. This chamber may or may not communicate outwardly by a long, narrow gallery (*allée couverte*). The mound may or may not have one or more rows of stones encircling it. And, finally, the stone structure may be on top of a mound of earth, instead of beneath it!

The simplest form of dolmen, if indeed it can be compared to the more elaborate structures bearing the same name, consists of several standing stones supporting one or more stones which rest upon them horizontally. If the roofing-stones rest with one end upon the ground, then it is called a demi-dolmen. A holed dolmen has one of the supporting stones (which generally forms one side of a square chamber) perforated. The demi-dolmens are not sufficiently specialized to establish any line of distribution. The holed dolmens are found in France and in India, and their curious resemblance has led many to believe in their common origin.

In the mound-covered dolmens a relationship is also seen between

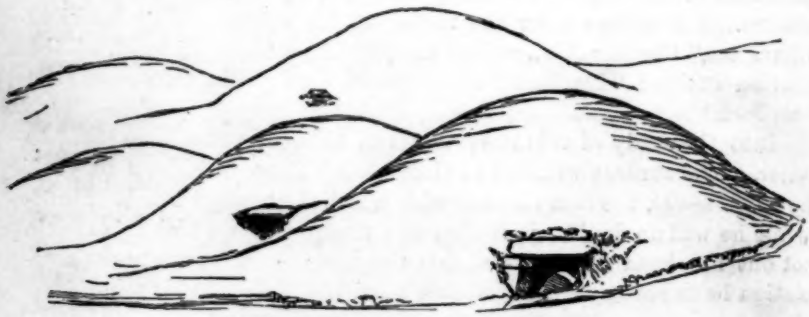

FIG. 1.—GENERAL APPEARANCE OF DOLMENS.

those of Brittany and Scandinavia, in the passageway generally opening toward the south or east and never to the north.*

From the mass of observations brought together regarding the dolmens, Mr. Fergusson † has prepared a map showing their distribution in the Old World. From this map, dolmens are found to occur in the greatest number in France. They are also found in various parts of Great Britain, more abundantly on the eastern coast of Ireland,

* Lubbock, "Prehistoric Times," p. 124.

† Fergusson, "Rude Stone Monuments," 1872.

western coast of Wales, eastern coast of Scotland, southern portion of Sweden, and in Denmark and Northern Germany; also on the coast of Spain, Portugal, Northern Africa and the western portion of India. Mr. Fergusson, at the date of the publication of his book, asserts that the typical dolmen had not yet been found in America.

The occurrence in different parts of the world of a mound of earth containing a stone vault or chamber can not be looked upon as evidence of a community of origin, because such a structure seems to be a most natural form for the purposes of burial. The same structures

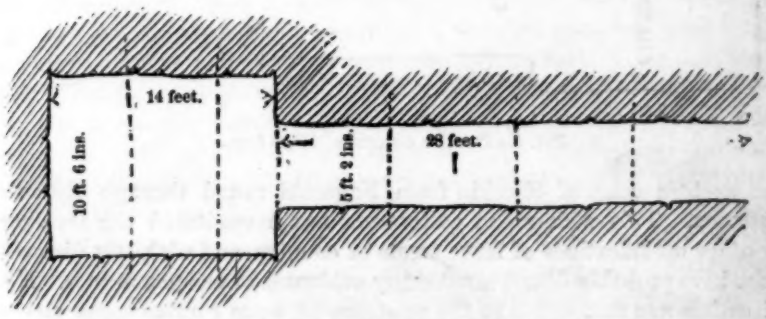

FIG. 2.—PLAN OF CHAMBER. The dotted lines show the roofing-stones.

are built to-day in many countries. It is only when it possesses some peculiar feature, like a perforation in one of its wall-stones, or a certain direction in which the passageway opens, that it suggests the idea that a common origin may be ascribed to those possessing these peculiarities.

In traveling across the southern part of Yeso last year, and also in a journey overland from the northern part of Japan to Tokio, I scanned the country carefully for mounds or monuments of any description. At the entrances of towns, one often sees two large mounds between which the road runs. Each mound is often surmounted by a large tree. Though these mounds are old, they are not prehistoric. With the exception of these, I saw nothing that would suggest a monument coming under the names of dolmen, menhir, etc.

There are many burial-mounds in Japan, such, for example, as the large one in Yamato, the grave of Jimmu Tenno, and others which are known to belong to historic periods. It is not improbable that the dolmens to be described belong to the same category.

It is difficult for one who has not traveled in Japan to realize the almost universal state of cultivation the country is under. Having a population of 33,000,000, largely given to agriculture, with an area not exceeding 80,000 square miles, one may imagine how few tracts of uncultivated land are found. One is amazed at the sight of ranges of hills and mountains extending for miles, and all terraced to their

very summits, for the cultivation of wheat and other products. The lower levels for miles are ditched and diked for rice-cultivation. This is specially marked along the coast bordering the Inland Sea, and along

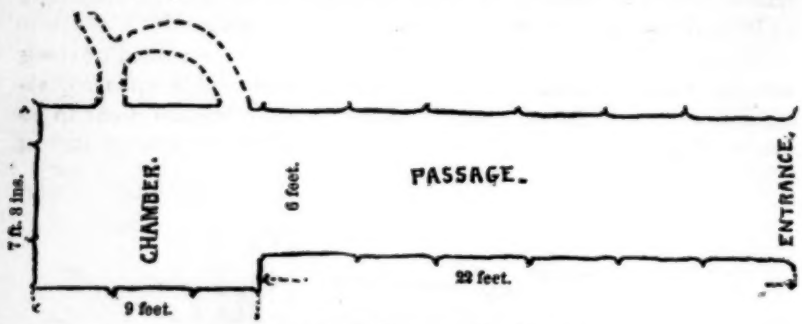

FIG. 3.—PLAN OF CHAMBER. Usual form.

the western coast of Kiushiu from Nagasaki round through Higo to Satsuma. This widespread cultivation has necessitated the leveling or other modifications of large tracts of country, and with this disturbance have probably disappeared many evidences of an ancient race. My attention was first called to the existence of some curious stone structures near Osaka, by Professor Yatabe, of the University of Tokio, who had received a letter from Mr. Ogawa, of the college at Osaka, with the request that I should examine them. This letter, accompanied by a few sketches, was published by Professor Yatabe in a Japanese periodical in Tokio.

On my return from an expedition to the southern portion of the empire, I visited Osaka with my assistant, Mr. Tanada, for the purpose of examining these structures. Mr. Ogawa and Mr. Amakusa, both teachers in the Osaka College, kindly accompanied me and rendered much assistance in the work of exploration. Our time was too limited to do more than make a hasty reconnaissance. We left Osaka early in the morning by *jinrikishas* (vehicles drawn by coolies), our way leading across extensive rice-fields, and our course directed to a range of low mountains about ten miles away. The country was as flat as a prairie, and had evidently been the floor of the sea at no remote geological period.

The dolmens are found in the villages Hattori Gawa and Kori Gawa, which lie at the base of a low chain of mountains. Having reached Hattori Gawa, we left our *jinrikishas*, and hunted up the headman of the village who was to accompany us to the dolmens.

Providing ourselves with candles, we started up a rather steep road, and after a while diverged to the left, down through a tangled ravine —stopping at the door of a temple to examine an old pot which was brought out for our inspection, and which proved to be a piece of Bizen-ware, not very old. Shortly after, we came to a group of dolmens.

They are widely scattered in groups of several along the slopes of the mountains for a considerable distance; and their general appearance is not unlike the mounds of Upsala, Sweden, as represented in the frontispiece of Lubbock's "Prehistoric Times."

The structures consist of stone chambers covered by mounds of earth, communications with the chamber being by means of a long, straight, narrow passage—a typical *allée couverte*. The apices of the mounds are not so pointed as in the figure of Lubbock, and their slopes not so steep (see Fig. 1). They average fifteen to twenty feet in

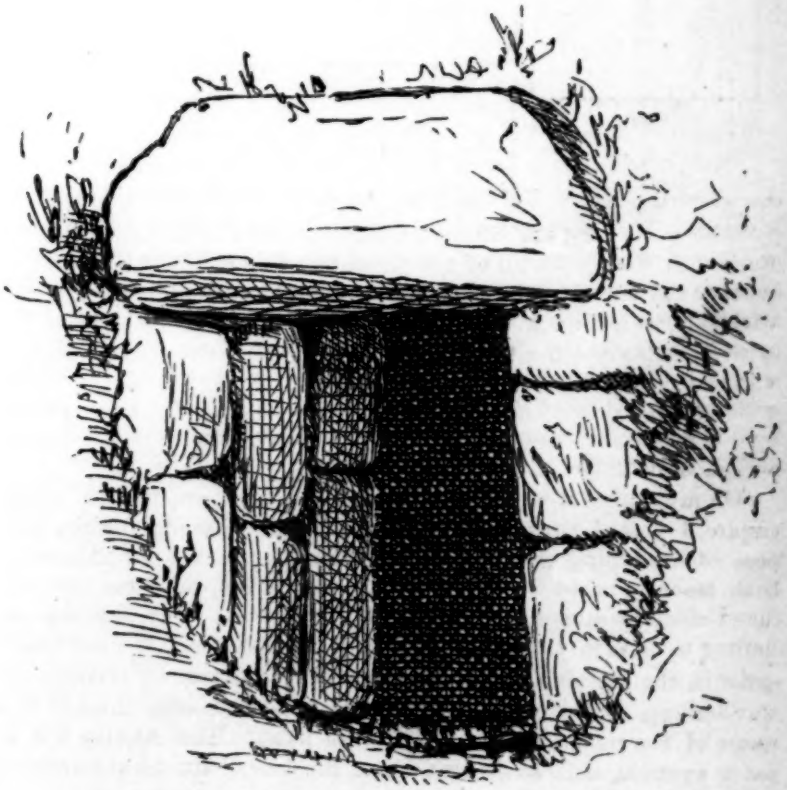

FIG. 4.—ENTRANCE TO CHAMBER.

height, and fifty to seventy-five feet in diameter. The entrances to most of the chambers are partially obstructed by dirt and stone which have tumbled from the sides and roof of the entrance. The stones composing the walls of the passageway and chamber were not large. In every case, however, the roofing-stones, both of the passageway and chamber, were of very large size. In some cases the entire roof of the chamber consisted of a single stone, and in one case four huge blocks formed the roof of a passageway twenty-eight feet long (see Fig. 2).

In every case, too, the stone which covered the passageway adjoining the chamber and forming part of its wall was of great size. The variation in the length of the passageways is due to their partial destruction. The other dimensions are quite uniform, as will be seen by comparing the following measurements of nine chambers, taken at random:

Length of Chamber.	Breadth of Chamber.	Height of Chamber.	Length of Passageway.	Breadth of Passageway.	Height of Passageway.
14·0	10·6	11·6	28	4·3	5·3
9·0	7·3	8·6	22	5·6	5·8
14·0	11·8	8·9	7	4·5	5·0
13·0	7·0	8·8	20	4·6	5·0
14·0	6·4	8·6	14	4·3	5·0
11·0	5·6	8·7	11	3·6	5·3
12·0	5·8	8·3	*	4·1	5·0
12·4	8·2	12·0	*	4·4	6·0
13·8	7·9	10·2	*	5·0	6·3

The plans vary but little—a single chamber, with the right wall flush with the right wall of the passageway, as in Fig. 3; or else the passageway entering the chamber on a median line, leaving a jog on each side, as in Fig. 2. Mr. Ogawa informed me that he had seen one with a small supplementary chamber leading from the end of the larger chamber.

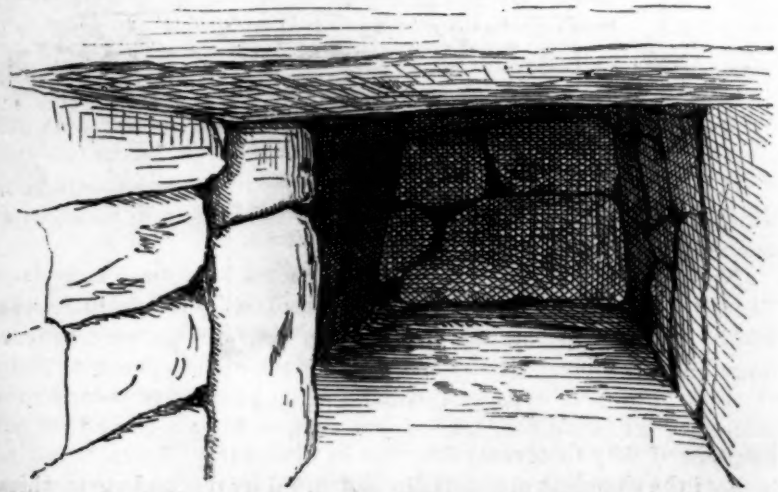

Fig. 5.—Appearance of Chamber from Passageway.

The passageway was nearly a foot narrower at the top than at the base, and in some cases was slightly narrower at the entrance.

In one case only were there signs that the chamber had been used

* Passageway partially destroyed. Measurement in feet and inches.

as a place of residence. A small opening between two of the wall-stones at the base of one of the chambers appeared blackened by fire. By removing the dirt and smaller stones which had tumbled down, I managed with some difficulty to crawl into an irregular flue which was blackened with smoke. This flue communicated with another smaller flue leading back into the chamber (see Fig. 2).

A rude sort of plaster was observed in some of the caves.

The walls of all the caves examined were carefully scrutinized to detect if possible signs of tool-marks or inscriptions, but nothing of the kind was observed. A careful search was made also for relics of some kind, but the floors were equally bare. Trenches were also dug down to the undisturbed soil, but no traces of pottery or implement of any description was found. This result is not surprising, when it is known that during the feudal days these chambers were often used as places of refuge for outlaws or political refugees, and during these times the earlier relics were probably removed or destroyed.

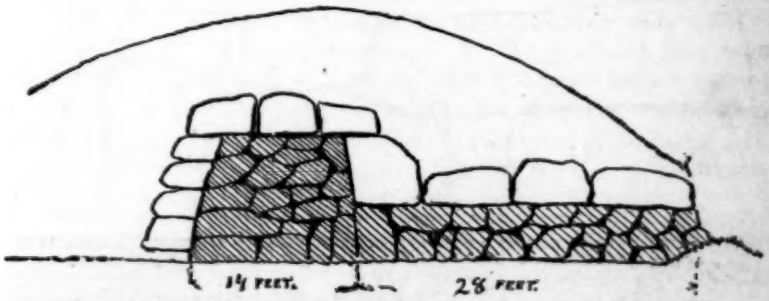

FIG. 6.—LONGITUDINAL SECTION OF DOLMEN, SHOWING CHAMBER AND PASSAGEWAY.

History records the fact that the governors of various provinces in which underground shelters occur ordered the closing of these places as a necessary measure.

No great antiquity can probably be assigned to these structures. That they are over a thousand years old there can be no doubt.* I am told by Japanese scholars that their early records call attention to these megalithic chambers existing in different parts of the country. Many of them have been destroyed, either for the purpose of securing the stone they contained for building materials, or to gain ground for cultivation.

In the vicinity of the dolmens and in the paths leading to them,

* In Fergusson's work, already alluded to, there is figured a dolmen of Uby, Scandinavia, page 311, and Antiquera, Spain, page 383, which resemble in many features the dolmens near Osaka. Jewitt also, in his work entitled "Grave-Mounds and their Contents," figures the dolmen of New Grange, Meath, Ireland, page 57, and the cairn of Howth, Ireland, page 58, which again recall similar features to those of the dolmens described in this article. In the cairn of Howth the passageway is twenty-seven feet long.

fragments of a hard, blue, unglazed pottery were found; and these fragments are identical with vessels dug up in various parts of the empire, which are regarded by Japanese archæologists as being of Corean origin, from nine to twelve hundred years old.

At the same meeting of the Boston Society of Natural History in which I communicated the results embodied in this paper, Professor F. W. Putnam announced the discovery of chambered mounds in

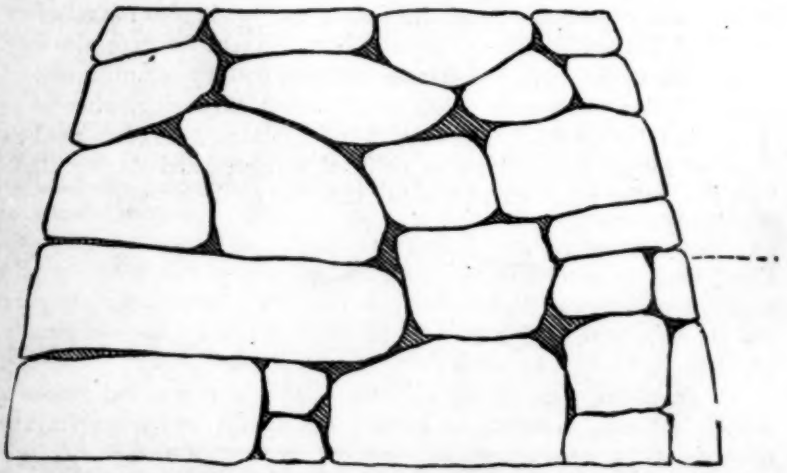

FIG. 7.—SHOWING ARRANGEMENT OF STONES IN SIDE-WALL OF CHAMBER. Length, 14 feet; height, 11 feet 6 inches. The dotted line to the right shows roof of passageway.

America, and communicated the following, which is taken from advance sheets of the "Proceedings" of that Society:

These chambered mounds are situated in the eastern part of Clay County, Missouri, and form a large group on both sides of the Missouri River. The chambers are, in the three opened by Mr. Curtiss, about eight feet square, and from four and a half to five feet high, each chamber having a passageway several feet in length and two in width, leading from the southern side, and opening on the edge of the mound formed by covering the chamber and passageway with earth. The walls of the chambered passages were about two feet thick, vertical, and well made of stones which were evenly laid, without clay or mortar of any kind. The top of one of the chambers had a covering of large, flat rocks, but the others seem to have been closed over with wood. The chambers were filled with clay which had been burned, and appeared as if it had fallen in from above. The inside walls of the chambers also showed signs of fire. Under the burned clay, in each chamber, were found the remains of several human skeletons, all of which had been burned to such an extent as to leave but small fragments of the bones, which were mixed with the ashes and charcoal. Mr. Curtiss thought that in one chamber he found the remains of five skeletons and in another thirteen. With these skeletons there were a few flint implements and minute fragments of vessels of clay.

A large mound near the chambered mounds was also opened, and in this no chambers were found. Neither had the bodies been burned. This mound proved remarkably rich in large flint implements, and also contained well-made pottery, and a peculiar "gorget" of red stone. The connection of the people who placed the ashes of their dead in the stone chambers with those who buried their dead in the earth-mounds is, of course, yet to be determined.

THE STUDY OF POLITICAL ECONOMY.*

By HENRY GEORGE.

I TAKE it that these lectures are intended to be more suggestive than didactic, and in what I shall have to say to you my object will be merely to induce you to think for yourselves. I shall not attempt to outline the laws of political economy, nor even, where my own views are strong and definite, to touch upon unsettled questions. But I want to show you, if I can, the simplicity and certainty of a science too generally regarded as complex and indeterminate, to point out the ease with which it may be studied, and to suggest reasons which make that study worthy of your attention.

Of the importance of the questions with which political economy deals it is hardly necessary to speak. The science which investigates the laws of the production and distribution of wealth concerns itself with matters which among us occupy more than nine tenths of human effort, and perhaps nine tenths of human thought. In its province are included all that relates to the wages of labor and the earnings of capital; all regulations of trade; all questions of currency and finance; all taxes and public disbursements—in short, everything that can in any way affect the amount of wealth which a community can secure, or the proportion in which that wealth will be distributed between individuals. Though not the science of government, it is essential to the science of government. Though it takes direct cognizance only of what are termed the selfish instincts, yet in doing so it includes the basis of all higher qualities. The laws which it aims to discover are the laws by virtue of which states wax rich and populous, or grow weak and decay; the laws upon which depend the comfort, happiness, and opportunities of our individual lives. And as the development of the nobler part of human nature is powerfully modified by material conditions, if it does not absolutely depend upon them, the laws sought for by political economy are the laws which at last control the mental and moral as well as the physical states of humanity.

Clearly, this is the science which of all sciences is of the first importance to us. Useful and sublime as are the sciences which open to

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us the vistas of Nature—which read for us the story of the deep past, or search out the laws of our physical or mental organization—what is their practical importance as compared with the science which deals with the conditions that alone make the cultivation of the others possible? Compare on this ground of practical utility the science of political economy with all others, and its preëminence almost suggests the reply of the Greek: "No, I can not play the fiddle; but I *can* tell you how to make of a little village a great and glorious city!"

How is it, then, it will naturally be asked, that a science so important is so little regarded? Our laws persistently violate its first and plainest principles, and that the ignorance thus exemplified is not confined to what are called the uneducated classes is shown by the debates in our legislative bodies, the decisions of our courts, the speeches of our party leaders, and the editorials of our newspapers. A century has elapsed since Adam Smith published his "Wealth of Nations," and sixty years since Ricardo enunciated his theory of rent. Yet not only has political economy received no substantial improvement since Ricardo, but, while thousands of new discoveries in other branches of human knowledge have been eagerly sized and generally utilized, and the most revolutionary conclusions of other sciences become part of the accepted data of thought, the truths taught by political economy seem to have made little real impression, and it is even now a matter of debate whether there is, or can be, such a science at all.

This can not be on account of the paucity of politico-economic literature. Enough books have been written on the subject within the last hundred years to fill a large library, while all of our great institutions of learning have some sort of a chair of political economy, and matters of intense public interest in which the principles of the science are directly involved are constantly being discussed.

It seems to me that the reasons why political economy is so little regarded are referable partly to the nature of the science itself and partly to the manner in which it has been cultivated.

In the first place, the very importance of the subjects with which political economy deals raises obstacles in its way. The discoveries of other sciences may challenge pernicious ideas, but the conclusions of political economy involve pecuniary interests, and thus thrill directly the sensitive pocket-nerve. For, as no social adjustment can exist without interesting a larger or smaller class in its maintenance, political economy at every point is apt to come in contact with some interest or other which regards it as the silversmiths of Ephesus did those who taught the uselessness of presenting shrines to Diana. Macaulay has well said that, if any large pecuniary interest were concerned in denying the attraction of gravitation, that most obvious of physical facts would not lack disputers. This is just the difficulty that has beset and still besets the progress of political economy. The man who is, or who imagines that he is, interested in the maintenance of a protective

tariff, may accept all your professors choose to tell him about the composition of the sun or the evolution of species, but, no matter how clearly you demonstrate the wasteful inutility of hampering commerce, he will not be convinced. And so, to the man who expects to make money out of a railroad-subsidy, you will in vain try to prove that such devices to change the natural direction of labor and capital must cause more loss than gain. What, then, must be the opposition which inevitably meets a science that deals with tariffs and subsidies, with banking interests and bonded debts, with trades-unions and combinations of capital, with taxes and licenses and land-tenures! It is not ignorance alone that offers opposition, but ignorance backed by interest, and made fierce by passions.

Now, while the interests thus aroused furnish the incentive, the complexity of the phenomena with which political economy deals makes it comparatively easy to palm off on the unreasoning all sorts of absurdities as political economy. And, when all kinds of diverse opinions are thus promulgated under that name, it is but natural that the great number of people who depend on others to save themselves the trouble of thinking should look upon political economy as a field wherein any one may find what he pleases. But what is far worse than any amount of pretentious quackery is, that the science even as taught by the masters *is* in large measure disjointed and indeterminate. As laid down in the best text-books, political economy is like a shapely statue but half hewn from the rock—like a landscape, part of which stands out clear and distinct, but over the rest of which the mists still roll. This is a subject into which, in a lecture like this, I can not enter; but, that it is so, you may see for yourselves in the failure of political economy to give any clear and consistent answer to most important practical questions—such as the industrial depressions which are so marked a feature of modern times, and in confusions of thought which will be obvious to you if you carefully examine even the best treatises. Strength and subtilty have been wasted in intellectual hair-splitting and super-refinements, in verbal discussions and disputes, while the great high-roads have remained unexplored. And thus has been given to a simple and attractive science an air of repellent abstruseness and uncertainty.

And springing, as it seems to me, from the same fundamental cause, there has arisen an idea of political economy which has arrayed against it the feelings and prejudices of those who have most to gain by its cultivation. The name of political economy has been constantly invoked against every effort of the working classes to increase their wages or decrease their hours of labor. The impious doctrine always preached by oppressors to oppressed—the blasphemous dogma that the Creator has condemned one portion of his creatures to lives of toil and want, while he has intended another portion to enjoy "all the fruits of the earth and the fullness thereof"—has been preached to

the working classes in the name of political economy, just as the "cursed-be-Ham" clergymen used to preach the divine sanction of slavery in the name of Christianity. In so far as the real turning questions of the day are concerned, political economy seems to be considered by most of its professors as a scientific justification of all that is, and by the convenient formula of supply and demand they seem to mean some method which Providence has of fixing the rate of wages so that it can never by any action of the employed be increased. Nor is it merely ignorant pretenders who thus degrade the name and terms of political economy. This character has been so firmly stamped upon the science itself as currently held and taught that not even men like John Stuart Mill have been able to emancipate themselves. Even the intellectually courageous have shrunk from laying stress upon principles which might threaten great vested interests; while others, less scrupulous, have exercised their ingenuity in eliminating from the science everything which could offend those interests. Take the best and most extensively circulated text-books. While they insist upon freedom for capital, while they justify on the ground of utility the selfish greed that seeks to pile fortune on fortune, and the niggard spirit that steels the heart to the wail of distress, what sign of substantial promise do they hold out to the workingman save that he should refrain from rearing children?

What can we expect when hands that should offer bread thus hold out a stone? Is it in human nature that the masses of men, vaguely but keenly conscious of the injustice of existing social conditions, feeling that they are somehow cramped and hurt, without knowing what cramps and hurts them, should welcome truth in this partial form; that they should take to a science which, as it is presented to them, seems but to justify injustice, to canonize selfishness by throwing around it the halo of utility, and to present Herod rather than Vincent de Paul as the typical benefactor of humanity? Is it to be wondered at that they should turn in their ignorance to the absurdities of protection and the crazy theories generally designated by the name of socialism?

I have lingered to inquire why political economy has in popular apprehension acquired the character of indefiniteness, abstruseness, and selfishness, merely that I may be the better able to convince you that none of these qualities properly belong to it. I want to draw you to its study by showing you how clear and simple and beneficent a science it is, or rather should be.

Although political economy deals with various and complicated phenomena, yet they are phenomena which may be resolved into simple elements, and which are but the manifestations of familiar principles. The premises from which it makes its deductions are truths of which we are all conscious and upon which in every-day life we constantly base our reasoning and our actions. Its processes, which consist

chiefly in analysis, have a like certainty, although, as with all the causes of which it takes cognizance are at all times acting other causes, it can never predict exact results but only tendencies.

And, although in the study of political economy we can not use that potent method of experiment by artificially produced conditions which is so valuable in the physical sciences, yet, not only may we find, in the diversity of human society, experiments already worked out for us, but there is at our command a method analogous to that of the chemist, in what may be called mental experiment. You may separate, combine, or eliminate conditions in your own imagination, and test in this way the working of known principles. This, it seems to me, is the great tool of political economy. It is a method with which you must be familiar and doubtless use every day, though you may never have analyzed the process. Let me illustrate what I mean by something which has no reference to political economy.

When I was a boy I went down to the wharf with another boy to see the first iron steamship which had ever crossed the ocean to our port. Now, hearing of an iron steamship seemed to us then a good deal like hearing of a leaden kite or a wooden cooking-stove. But, we had not been long aboard of her, before my comrade said in a tone of contemptuous disgust: "Pooh! I see how it is. She's all lined with wood; that's the reason she floats." I could not controvert him for the moment, but I was not satisfied, and, sitting down on the wharf when he left me, I set to work trying mental experiments. If it was the wood inside of her that made her float, then the more wood the higher she would float; and, mentally, I loaded her up with wood. But, as I was familiar with the process of making boats out of blocks of wood, I at once saw that, instead of floating higher, she would sink deeper. Then, I mentally took all the wood out of her, as we dug out our wooden boats, and saw that thus lightened she would float higher still. Then, in imagination, I jammed a hole in her, and saw that the water would run in and she would sink, as did our wooden boats when ballasted with leaden keels. And, thus I saw, as clearly as though I could have actually made these experiments with the steamer, that it was not the wooden lining that made her float, but her hollowness, or, as I would now phrase it, her displacement of water.

Now, just such mental operations as these you doubtless perform every day, and in doing so you employ the method of imaginative experiment which is so useful in the investigations of political economy. You can, in this way, turn around in your mind a proposition or phenomenon and look on all sides of it, can isolate, analyze, recombine, or subject it to the action of a mental magnifying glass which will reveal incongruities as a *reductio ad absurdum*. Let me again illustrate:

Before I had ever read a line of political economy, I happened once to hear a long and well-put argument in favor of a protective tariff. Up to that time I had supposed that "protection to domestic industry"

was a good thing; not that I had ever thought out the matter, but that I had accepted this conclusion because I had heard many men whom I believed wiser than I say so. But this particular speaker had, so far as one of his audience was concerned, overshot his mark. His arguments set me thinking, just as when a boy my companion's solution of the iron-ship mystery had set me thinking. I said to myself: The effect of a tariff is to increase the cost of bringing goods from abroad. Now, if this benefits a country, then all difficulties, dangers, and impediments which increase the cost of bringing goods from abroad are likewise beneficial. If this theory be correct, then the city which is the hardest to get at has the most advantageous situation: pirates and shipwrecks contribute to national prosperity by raising the price of freight and the cost of insurance; and improvements in navigation, in railroads and steamships, are injurious. Manifestly this is absurd.

And then I looked further. The speaker had dwelt on the folly of a great country like the United States exporting raw material and importing manufactured goods which might as well be made at home, and I asked myself, What is the motive which causes a people to export raw material and import manufactured goods? I found that it could be attributed to nothing else than the fact that they could in this way get the goods cheaper, that is, with less labor. I looked to transactions between individuals for parellels to this trade between nations, and found them in plenty—the farmer selling his wheat and buying flour; the grazier sending his wool to a market and bringing back cloth and blankets; the tanner buying back leather in shoes, instead of making them himself. I saw, when I came to analyze them, that these exchanges between nations were precisely the same thing as exchanges between individuals; that they were, in fact, nothing but exchanges between individuals of different nations; that they were all prompted by the desire and led to the result of getting the greatest return for the least expenditure of labor; that the social condition in which such exchanges did not take place was the naked barbarism of the Terra del Fuegians; that just in proportion to the division of labor and the increase of trade were the increase of wealth and the progress of civilization. And so, following up, turning, analyzing, and testing all the protectionist arguments, I came to conclusions which I have ever since retained.

Now, just such mental operations as this are all that is required in the study of political economy. Nothing more is needed (but this *is* needed) than the habit of careful thought—the making sure of every step without jumping to conclusions. This habit of jumping to conclusions—of considering essentially different things as the same because of some superficial resemblance—is the source of the manifold and mischievous errors which political economy has to combat.

But I can probably, by a few examples, show you what I mean more easily than in any other way. Were I to put to you the child's

question, "Which is heavier, a pound of lead or a pound of feathers?" you would doubtless be offended; and were I seriously to ask you, Which is the most valuable, a dollar's worth of gold or a dollar's worth of anything else? you might also feel that I had insulted your intelligence. Yet the belief that a dollar's worth of gold is more valuable than a dollar's worth of anything else is widespread and persistent. It has molded the policy of great nations, dictated treaties, marched armies, launched fleets, fought battles, constructed and enforced elaborate and vexatious systems of taxation, and sent men by thousands to jail and to the gallows. Certainly a large portion, probably a large majority, of the people of the United States—including many college graduates, members of what are styled the learned professions, senators, representatives, authors, and editors—seem to-day utterly unable to get it fully through their heads that a dollar's worth of anything else is as valuable as a dollar's worth of the precious metals, and are constantly reasoning, arguing, and legislating on the assumption that the community which exchanges gold for goods is suffering a loss, and that it is the part of wisdom, by preventing such exchange, to "keep money in the country." On this absurd assumption the revenue system of the United States is based to-day, and, if you will notice, you will find it cropping out of current discussions in all sorts of forms. Even here, where the precious metals form one of our staples, and for a long time constituted our only staple, you may see the power of the same notion. The anti-cooly clubs complain of the "drain of money to China," but never think of complaining of the drain of flour, wheat, quicksilver, or shrimps. And the leading journals of San Francisco, who hold themselves on an immeasurably higher intellectual level than the anti-cooly clubs, never, I think, let a week pass without congratulating their readers that we have ceased to import this or that article, and are thereby keeping so much money that we used to send abroad, or lamenting that we still send money away to pay for this or that which might be made here. Yet that we send away wine or wool, fruit or honey, is never thought of as a matter of lament, but quite the contrary. What is all this but the assumption that a dollar's worth of gold is worth more than a dollar's worth of anything else?

This fallacy is transparently absurd when we come to reduce it to a general proposition. But, nevertheless, the habit of jumping at conclusions, of which I have spoken, makes it seem very natural to people who do not stop to think. Money is our standard, or measure of values, in which we express all other values. When we speak of gaining wealth, we speak of "making money"; when we speak of losing wealth, we speak of "losing money"; when we speak of a rich man, we speak of him as possessed of much money, though as a matter of fact he may, and probably has, very little actual money. Then, again, as money is the common medium of exchange, in the

process of getting things we want for things we are willing to dispose of, we generally first exchange the latter for money and then exchange the money for the things we want. And, as the number of people who want things of all sorts must manifestly be greater than the number of people who want the particular thing, whatever it may be that we have to exchange, any difficulty there may be in making our exchange will generally attend the first part of it; for, in exchanging anything for money, I must find some one who wants my particular thing, while in exchanging money for a commodity, any one who wants any commodity or service will be willing to take my money. Now, this habit of estimating wealth in money, and of speaking of gain or loss of wealth as gain or loss of money, and this habit of associating difficulties of exchange in individual cases with the difficulty of obtaining money, constantly lead people who do not think clearly to jump at the conclusion that money is more valuable than anything else. Yet the slightest consideration would show them that wealth never consists, but in very small part, of money; that the difficulty in individual exchanges has no reference to the relative value of money, and is eliminated when the exchanges of large numbers of individuals are concentrated or considered, and, in short, a dollar in money is worth no more than a dollar's worth of wheat or cloth; and that, instead of the exchange of money for other commodities being proof of a disadvantageous bargain, it is proof of an advantageous bargain, for, if we did not want the goods more than the money, we would not make the exchange.

Or, to take another example: In connection with the discussion of Chinese immigration, you have, doubtless, over and over again heard it contended that cheap labor, which would reduce the cost of production, is precisely equivalent to labor-saving machinery, and, as machinery operates to increase wealth, so would cheap labor. This conclusion is jumped at from the fact that cheap labor and labor-saving machinery similarly reduce the cost of production to the manufacturer. But, if, instead of jumping at this conclusion, we analyze the manner in which the reduction of cost is produced in each case, we shall see the fallacy. Labor-saving machinery reduces cost by increasing the productive power of labor; a reduction of wages reduces cost by reducing the share of the product which falls to the laborer. To the employer the effect may be the same; but, to the community, which includes both employers and employed, the effect is very different. In the one case there is increase in the general wealth; in the other there is merely a change in distribution—whatever one class gains another class necessarily losing. Hence the effect of cheap labor is necessarily very different from that of improved machinery.

And precisely similar to this fallacy is that which seems so natural to men of another class—that because the introduction of cheaper

labor in any community *does*, in the present organization of society, tend to reduce the general level of wages, so does the importation of cheap goods. This, also—but I must leave you to analyze it for yourselves—springs from a confusion of thought which does not distinguish between the whole and the parts, between the distribution of wealth and the production of wealth.

Did time permit, I might go on, showing you by instance after instance how transparently fallacious are many current opinions—some, even, more widely held than any of which I have spoken—when tried by the simple tests which it is the province of political economy to apply. But my object is not to lead you to conclusions. All I wish to impress upon you is the real simplicity of what is generally deemed an abstruse science, and the exceeding ease with which it may be pursued. For the study of political economy you need no special knowledge, no extensive library, no costly laboratory. You do not even need text-books nor teachers, if you will but think for yourselves. All that you need is care in reducing complex phenomena to their elements, in distinguishing the essential from the accidental, and in applying the simple laws of human action with which you are familiar. Take nobody's opinion for granted; "try all things: hold fast that which is good." In this way, the opinions of others will help you by their suggestions, elucidations, and corrections; otherwise they will be to you but as words to a parrot.

If there were nothing more to be urged in favor of the study of political economy than the mental exercise it will give, it would still be worth your profoundest attention. The study which will teach men to think for themselves is the study of all studies most needed. Education is not the learning of facts; it is the development and training of mental powers. All this array of professors, all this paraphernalia of learning, can not educate a man. They can but help him to educate himself. Here you may obtain the tools; but they will be useful only to him who can use them. A monkey with a microscope, a mule packing a library, are fit emblems of the men—and, unfortunately, they are plenty—who pass through the whole educational machinery, and come out but learned fools, crammed with knowledge which they can not use—all the more pitiable, all the more contemptible, all the more in the way of real progress, because they pass, with themselves and others, as educated men.

But, while it seems to me that nothing can be more conducive to vigorous mental habits and intellectual self-reliance than the study which trains us to apply the analysis of thought to the every-day affairs of life, and to see in constantly changing phenomena the evidence of unchanging law; which leads us to distinguish the real from the apparent, and to mark, beneath the seething eddies of interest, passion, and prejudice, the great currents of our times—it is not on such incentives that I wish to dwell. There are motives as much

higher than the thirst for knowledge, as that noble passion is higher than the lust for power or the greed of gold.

In its calculations the science of wealth takes little note of, nay, it often carefully excludes, the potent force of sympathy, and of those passions which lead men to toil, to struggle, even to die for the good of others. And yet it is these higher passions, these nobler impulses, that urge most strenuously to its study. The promise of political economy is not so much what it may do for you, as what it may enable you to do for others.

I trust you have felt the promptings of that highest of ambitions—the desire to be useful in your day and generation; the hope that in something, even though little, those who come after may be wiser, better, and happier that you have lived. Or, if you have never felt this, I trust the feeling is only latent, ready to spring forth when you see the need.

Gentlemen, if you but look, you will see the need! You are of the favored few, for the fact that you are here, students in a university of this character, bespeaks for you the happy accidents that fall only to the lot of the few, and you can not yet realize, as you may by and by realize, how the hard struggle which is the lot of so many may cramp and bind and distort—how it may dull the noblest faculties and chill the warmest impulses, and grind out of men the joy and poetry of life; how it may turn into the lepers of society those who should be its adornment, and transmute, into vermin to prey upon it and into wild beasts to fly at its throat, the brain and muscle that should go to its enrichment! These things may never yet have forced themselves on your attention; but still, if you will think of it, you can not fail to see enough want and wretchedness, even in our own country to-day, to move you to sadness and pity, to nerve you to high resolve; to arouse in you the sympathy that dares, and the indignation that burns to overthrow a wrong.

And seeing these things, would you fain do something to relieve distress, to eradicate ignorance, to extirpate vice? You must turn to political economy to know their causes, that you may lay the axe to the root of the evil tree. Else all your efforts will be in vain. Philanthropy, unguided by an intelligent apprehension of causes, may palliate or it may intensify, but it can not cure. If charity could eradicate want, if preaching could make men moral, if printing books and building schools could destroy ignorance, none of these things would be known to-day.

And there is the greater need that you make yourselves acquainted with the principles of political economy from the fact that, in the immediate future, questions which come within its province must assume a greater and greater importance. To act intelligently in the struggle in which you must take part—for positively or negatively each of you must carry his weight—you must know something of this science.

And this, I think, is clear to whoever considers the forces that are mustering—that the struggle to come will be fiercer and more momentous than the struggles that are past.

There is a comfortable belief prevalent among us that we have at last struck the trade-winds of time, and that by virtue of what we call progress all these evils will cure themselves. Do not accept this doctrine without examination. The history of the past does not countenance it, the signs of the present do not warrant it. Gentlemen, look at the tendencies of our time, and see if the earnest work of intelligent men be not needed.

Look even here. Can the thoughtful man view the development of our State with unmixed satisfaction? Do we not know that, under present conditions, just as that city over the bay grows in wealth and population, so will poverty deepen and vice increase; that just as the liveried carriages become more plentiful, so do the beggars; that just as the pleasant villas of wealth dot these slopes, so will rise up the noisome tenement-house in the city slums. I have watched the growth of San Francisco with joy and pride, and my imagination still dwells with delight upon the image of the great city of the future, the queen of all the vast Pacific—perhaps the greatest city of the world. Yet what is the gain? San Francisco of to-day, with her three hundred thousand people, is, for the classes who depend upon their labor, not so good a place as the San Francisco of sixty thousand; and when her three hundred thousand rises to a million, San Francisco, if present tendencies are unchanged, must present the same sickening sights which in the streets of New York shock the man from the open West.

This is the dark side of our boasted progress, the Nemesis that seems to follow with untiring tread. Where wealth most abounds, there poverty is deepest; where luxury is most profuse, the gauntest want jostles it. In cities which are the storehouses of nations, starvation annually claims its victims. Where the costliest churches rear the tallest spires toward heaven, there is needed a standing army of policemen; as we build new schools, we build new prisons; where the heaviest contributions are raised to send missionaries to the ends of the earth to preach the glad tidings of peace and good-will, there may be seen squalor and vice that would affright a heathen. In mills where the giant power of steam drives machinery that multiplies by hundreds and thousands the productive forces of man, there are working little children who ought to be at play or at school; where the mechanism of exchange has been perfected to the utmost, there thousands of men are vainly trying to exchange their labor for the necessaries of life!

Whence this dark shadow that thus attends that which we are used to call "material progress," that which our current philosophy teaches us to hope for and to work for? Here is the question of all questions for us. We must answer it or be destroyed, as preceding

civilizations have been destroyed. For no chain is stronger than its weakest link, and our glorious statue with its head of gold and its shoulders of brass has as yet but feet of clay!

Political economy alone can give the answer. And, if you trace out, in the way I have tried to outline, the laws of the production and exchange of wealth, you will see the causes of social weakness and disease in enactments which selfishness has imposed on ignorance, and in maladjustments entirely within our own control.

And you will see the remedies. Not in wild dreams of red destruction nor weak projects for putting men in leading-strings to a brainless abstraction called the state, but in simple measures sanctioned by justice. You will see in light the great remedy, in freedom the great solvent. You will see that the true law of social life is the law of love, the law of liberty, the law of each for all and all for each; that the golden rule of morals is also the golden rule of the science of wealth; that the highest expressions of religious truth include the widest generalizations of political economy.

There will grow on you, as no moralizing could teach, a deepening realization of the brotherhood of man; there will come to you a firmer and firmer conviction of the fatherhood of God. If you have ever thoughtlessly accepted that worse than atheistic theory that want and wretchedness and brutalizing toil are ordered by the Creator, or, revolting from this idea, if you have ever felt that the only thing apparent in the ordering of the world was a blind and merciless fate careless of man's aspirations and heedless of his sufferings, these thoughts will pass from you as you see how much of all that is bad and all that is perplexing in our social conditions grows simply from our ignorance of law—as you come to realize how much better and happier men might make the life of man.

WARD'S NATURAL SCIENCE ESTABLISHMENT.

By Professor JOSEPH LEIDY.

A RECENT visit to Professor Henry A. Ward's "Natural Science Establishment" at Rochester, New York, led the writer to some reflections on the comparative value of a knowledge of natural history. In the prevailing systems of education, the subject is totally disregarded, or receives but trifling consideration. The classical languages and history, on the other hand, have always been taught, and are yet considered by the greater portion of the cultivated people as essential to a complete education, while the sciences have been treated as only of secondary importance. The information possessed by a country boy, gained by intelligent observation, of the birds or plants

of his neighborhood, is viewed by the so-called educated community as insignificant in comparison with that of the college boy who can relate stories, from classical history, of persons who never existed and events that never occurred.

Considering the circumstance that all things, except what we make of them, are natural objects, it would seem that the first and main efforts of education, after acquiring sufficient language and arithmetic to express our ideas of qualities and numbers, would be to learn what the objects are. The child on learning to speak at once begins to ask about the things it sees, but unfortunately too often the parent and teacher are incapable of giving the desired information, and ordinarily it meets with so little satisfaction that finally the spirit of inquiry disappears. For most persons, after distinguishing the ordinary articles pertaining to the necessities and conveniences of life, the crudest generalities of knowledge appear to be sufficient. With them it seems to be enough to know that things are stones, metals, and dirt; weeds, flowers, and trees; bugs, animals, and men. Among the cultivated, one is considered the no less educated if he calls a worm a snake, or a caterpillar a nasty reptile; while he may run the risk of being called ignorant, or at least uneducated, if he can not translate a Latin text. Though quartz is the most abundant mineral substance of the land in which we live, yet perhaps not one in a hundred of an educated community knows a quartz-pebble from any other.

To the writer the sciences, including natural history, have appeared to be of the utmost importance to the welfare and happiness of mankind, and no other branches of knowledge can equal them in these relations.

To facilitate the study and to create a more general interest in natural history, museums of characteristic specimens should not only be connected with every college and other educational institutions, but there should be established in every considerable town a free public museum—not a mere show or place of amusement, a collection of curiosities and rare specimens, queer things, a two-headed calf, or a dried hand of a murderer, but a series of specimens, often of familiar objects, illustrative of the classes, orders, and other chief divisions of the mineral, vegetal, and animal kingdoms, together with those which illustrate geology and kindred subjects. A museum of this kind should further be supplied with specimens of all the natural productions of the vicinity, which may be collected from time to time by those who are, or may become, most interested in the study of natural history. Such a museum would not only be of the greatest service as a means of instruction, but would prove useful in a variety of ways to the community, and would also give additional interest to the visits of strangers to the locality.

Professor Ward's great establishment is intended to supply a com-

plete series of illustrative specimens in all the departments of natural history for educational museums. The writer had repeatedly seen and admired collections of specimens from this establishment in colleges and other institutions, but it was only recently that he was induced to visit the former itself. It greatly exceeded his expectations, and surprised him by its extent as well as delighted him from the excellence and beauty of its collections. Many buildings were stored with admirably mounted and well-preserved vertebrates, snowy-white skeletons, a multitude of invertebrates, excellent models, fine collections of minerals, and characteristic series of rocks and fossils. Even in the great capitals of Europe nowhere did the writer see so great and excellent a stock from which to furnish museums; and it is in grateful appreciation of the able and zealous services of Professor Ward, in the interest of natural history, that the writer takes this opportunity of recommending his establishment to those who desire to obtain collections. In conclusion, to exemplify how much may be taught of whole groups or orders from a few specimens, the writer presents the following instance: He had in his possession a fragment of red coral, the material so much used for ornament. Notwithstanding much explanation, persons ordinarily appeared to him to be incredulous as to its animal nature. In viewing Professor Ward's collections, he espied among thousands of actual specimens a pair of beautiful models of the red coral, one representing the object of natural size covered with the soft flesh and exhibiting the tiny polyps; the other representing a magnified view, exhibiting a fragment of a stem with three polyps. These were purchased for one dollar each, and are now placed together with the natural coral fragment, and not only tell the whole story of the animal at a glance, but tell that of the whole order to which it belongs. Many such examples might be related, but one is enough.

It is this careful attention of Professor Ward to the scientific and educational import of his collections which has given his natural history establishment its high appreciation among the naturalists and the science teachers of our country.

THE FORCE BEHIND NATURE.

By WILLIAM B. CARPENTER, M. D., F. R. S.

SOME thirty years ago, I enjoyed opportunities of discussing with John Stuart Mill (whose younger brother had been for twelve months an inmate of my house) many questions of philosophy in which we both felt the deepest interest. Among these was the Doctrine of Causation set forth in his recently published "System of Logic": "We may define the cause of a phenomenon to be the ante-

cedent, or the concurrence of antecedents, on which it is invariably and unconditionally consequent." I pointed out to my friend that, when this assemblage of conditions is analyzed, it is uniformly found resolvable into two categories, which may be distinguished as the *dynamical* and the *material;* the former supplying the *force* or *power* to which the change must be attributed, while the latter affords the *conditions* under which that power is exerted. Thus, I urged, when a man falls from a ladder *because* (as is commonly said) of the breaking of the rung on which his foot was resting, the real or *dynamical* cause of his fall is the force of gravity, or attraction of the earth, which pulls him to the ground when his foot is no longer supported; the loss of support being only the *material condition* or *collocation*, which allowed the force previously acting as *pressure* on the rung to produce the downward *motion* of the man who stood upon it.

To this Mr. Mill's reply was, that the distinction is one of metaphysics, not of logic. I ventured, however, to press on him that, to whichever department of philosophy this point is to be referred, it is one of fundamental importance; that, assuming experience as the basis of our knowledge, we recognize the downward tendency of every body heavier than air, by our sense of muscular tension in lifting it from the ground, or in resisting its descent toward the earth; and that our cognition of *force* through this form of sensation, being thus quite as immediate and direct as our cognition of *motion* through the visual sense, ought to be equally taken account of.

The promulgation, about the same time, of the doctrine of the "Correlation of the Physical Forces" by Professor (now Sir William) Grove, and the researches of Mr. Joule on the "Mechanical Equivalent of Heat," seemed to me to bring this view of *dynamical* causation into yet greater importance, by showing that what is true of that form of force which produces or resists mechanical (or what is now distinguished as *molar*) motion, may be legitimately extended to those other forms which are manifested in the *molecular* changes that express themselves in chemical action, or impress us with the sensations of heat, light, etc. Partaking of the general ignorance at that time prevalent in this country of the doctrine of "Conservation of Energy," already promulgated in Germany by Mayer and Helmholtz, I myself endeavored to carry Professor Grove's principle into the domain of biology, by showing that what physiologists had been accustomed to call vital force may be regarded as having the same "correlation" with the various forms of physical force as they have with each other.* And in the introduction to the fourth edition of my "Human Physiology" (published in 1853) I thus explicitly defined my position:

> When this assemblage of antecedents is analyzed, it is uniformly found that they may be resolved into two categories, which may be distinguished as the *dy-*

* "On the Mutual Relations of the Vital and Physical Forces," in "Philosophical Transactions," 1850.

namical and the *material*, the former supplying the *force* or *power* to which the change must be attributed, while the latter afford the *conditions* under which that power is exerted. Thus, in a steam-engine we see the dynamical agency of heat made to produce mechanical power by the mode in which it is applied: first, to impart a mutual repulsion to the particles of water; and then, by means of that mutual repulsion, to give motion to the various solid parts of which the machine is composed. And thus, if asked what is the cause of the movement of the steam-engine, we distinguish in our reply between the *dynamical* condition supplied by the heat and the *material* condition (or assemblage of conditions) afforded by the "collocation" of the boiler, cylinder, piston, valves, etc. . . . In like manner, if we inquire into the cause of the germination of a seed—which has been brought to the surface of the earth after remaining dormant through having been buried deep beneath the soil for (it may be) thousands of years—we are told that the phenomenon depends upon warmth, moisture, and oxygen; but out of these we single warmth as the *dynamical* condition, while the oxygen and the water, with the organized structure of the seed itself, and the organic compounds which are stored up in its substance, constitute the *material*.

The subsequent general recognition by the scientific world of the "correlation" between the forces of nature (under whatever form expressed) has thus given a breadth of foundation to the dynamical doctrine of causation which it previously lacked; and the doctrine, having been afterward formally developed by Professor Bain, was summarized by J. S. Mill, in the later editions of his "Logic," almost in the very terms in which I had originally propounded it to him in conversation, and had publicly expressed it in the extract just cited: "The chief practical conclusion drawn by Professor Bain, bearing on causation, is that we must distinguish, in the assemblage of conditions which constitutes the cause of a phenomenon, two elements: one, the presence of a force; the other, the collocation or position of objects which is required in order that the force may undergo the particular transmutation which constitutes the phenomenon."* Mr. Mill himself still preferred, however, to express the principle in terms of motion rather than in terms of force: "If the effect, or any part of the effect, to be accounted for consists in putting matter in motion, then any of the objects present which has lost motion has contributed to the effect; and this is the true meaning of the proposition that the cause is that one of the antecedents which exerts active force." As this mode of expressing the facts is sanctioned by high authorities at the present time, it may be well for me to explain more fully the basis of my original contention, that our cognition of *force* is quite as immediate and direct as our cognition of *motion;* in fact (as I think I shall be able to prove), even more fundamental, inasmuch as our cognition of matter itself is in great degree dependent upon it.

It has been recently well said that "all true science involves both the knowledge of nature and the knowledge of man; it includes the study of mind, as well as of matter. A philosopher may pursue either,

* "System of Logic," eighth edition, vol. i., p. 406.

but he can have no complete knowledge of what he investigates, without borrowing from the other department of investigation."* Many of the Nature-philosophers who affirm that we have no knowledge of anything but the matter and motion which lie within the range of "experience" show themselves very imperfectly acquainted with what "experience" really means; unhesitatingly ranking as actual objective facts their own mental interpretations of the sensory impressions they receive from external objects. Many metaphysicians, on the other hand, have reasoned as if our concern were with mental operations alone, and as if the abstractions in which they deal had an existence *per se*, without any relation to the phenomena of nature. But, among the ablest thinkers of the present time, there seems to be now a pretty general recognition of the necessity for the replacement of the abstract definitions of metaphysics—so far, at least, as they relate to the external world—by psychological expressions of the modes in which the human *ego* is affected by its changes. Thus the ordinary metaphysical definition of "matter" is that which possesses "extension." But, for this definition to convey any definite idea to our minds, we must know what "extension" means; and this, we are told, is the "occupation of space." Now, the conception of "space," in the opinion of most psychologists, is ordinarily derived from our interpretation of *visual* sensations; and yet these may be altogether deceptive. When we look at a window from a short distance, we can not tell by the use of our eyes alone whether the space included by its frame is void, or is occupied by a perfectly transparent and colorless glass. A glass globe is held up in front of it, and we can not tell by looking at it whether it is empty, or is filled with pure water or some other transparent colorless liquid. And we can take no cognizance by our vision of the atmosphere which surrounds us, unless its transparence is interfered with by mist or fog. Clearly, then, our visual sense can not *per se* furnish us with a satisfactory definition of matter.†

Now that we have got rid of the fiction of "imponderables," we might fall back on a definition of matter—in use before that fiction was invented—as that which possesses "ponderosity" or weight. But what is weight? The downward tendency, it may be replied, in virtue of which all unsupported bodies fall to the earth. But what is

* "Natural Theology of the Doctrine of the Forces." By Professor Benjamin Martin, of the University of the City of New York.

† According to Professor Bain, the conception of space is essentially based on the sense of muscular tension which, according to him, we experience in the ordinary movements of our eyes. But I am satisfied that this is physiologically erroneous. These movements are ordinarily guided, as Professor Alison long ago contended, and as Professor Helmholtz and I myself have since experimentally proved, by the visual, not by the muscular sense; and it is only when we put the muscles to an unusual strain—as when our visual axes converge on an object brought nearer and nearer to the eyes, or when we entirely exclude light from the retina—that we experience any sense of tension in their muscles.

this "tendency"? We might *see* any number of bodies falling to the ground, and might frame a correct law of their motion, without having the remotest conception of their possessing that downward *pressure* which we at once recognize when we take a lump of lead or iron into our hands; and it is obviously on our cognition of this pressure, that our idea of weight or ponderosity is based. Now, the instrumentality through which we take cognizance of it seems to me to be threefold: In the first place, we have the sense of simple pressure on the tactile surface—as when, the hand passively resting on a table, a weight is laid upon it. Secondly, we recognize it by the sense of *tension* which we experience when a weight is attached to a pendent limb, and which we refer to the muscles and ligaments which are thus put on the stretch; or when, the hand resting on the top of a cylinder of glass placed over an air-pump, the air is exhausted from beneath, so as to make us *feel* the downward "pressure of the atmosphere." In these two cases, the mind is the passive recipient of the sensory impressions. But, thirdly, when we determinately lift a weight or hold it suspended by our hands, we experience, in addition to the sense of pressure and the sense of tension, a *sense of effort*, which we recognize as an *immediate* revelation of consciousness, not referable to any physical impression, but of the same kind as that which we experience in a purely mental act, such as the fixation of the attention. And a little consideration will, I think, make it clear that it is on this "sense of effort" in resisting downward pressure that our cognition of weight is essentially based.

For, in the first place, the *continuance* of a moderate pressure on the cutaneous surface, like other sensory impressions that become habitual, soon ceases to affect us sensorially; for we cognosce rather the *changes* in the states of our sense-organs than the states themselves. Or, again, we may suffer under a temporary or permanent paralysis of the cutaneous sense, that may prevent our feeling the contact of the body we are lifting or supporting; and yet, recognizing its downward pressure in other ways, we can put our muscles into action to antagonize it. But, secondly, this paralysis may extend to the muscular sense, so that the feeling of muscular tension is wanting as well as that of contact-pressure; and yet none the less can a weight be lifted or sustained by a conscious effort, provided that the deficiency of the guiding sensations ordinarily derived from the muscle itself is supplied by the sight. A woman whose arm is sensorially but not motorially paralyzed can hold up her child as long as she looks at it, and a man affected with the like paralysis of his legs can stand and walk while looking at his feet. But, thirdly, since the *mental sense of effort* is experienced in every determinate exercise of our muscular power, and is, as all experience teaches, a necessary condition of that exercise; since, again, it is proportioned to the exertion we put forth, and continues as long as that exertion is sustained—it is in this, and not in the cutaneous or

muscular impressions which are (so to speak) accidental, that (as it seems to me) we find the real basis of our cognition of the "ponderosity" of matter.

But "ponderosity" can not be considered an essential property of matter, being merely the "accident" of the earth's attraction for bodies lying within its range. This attraction varies with the distance of a body from the center of the earth; and a body occupying the common center of gravity of the earth and sun would be equally drawn toward both, and would consequently have no "weight." We must, therefore, seek a satisfactory definition of matter elsewhere; and we find the clew to it in the consideration that the sense of effort we experience in antagonizing the downward pressure of a body is but a particular case of our more general cognition of *resistance*. When we project our hand against a hard and fixed solid body, our consciousness of its resistance to our pressure is exactly that which we experience when we try to raise a weight that we have not strength to lift; while, if that solid be either yielding in its parts or movable as a whole, we measure its resistance, as in lifting a weight, by our sense of the effort necessary to overcome it. When we move our hand through a liquid, we are conscious of a resistance to its motion, which is greater or less according to the "viscosity" of the liquid. And, when we move our open hand through air at rest, we are still conscious of a resistance, our sense of it being augmented by an extension of the surface moved, as in the act of fanning; while, if the air is in motion, we feel its pressure on the sail of a boat by the "pull" of the sheet we hold in our hand, or on the sails of a windmill by the rotation it imparts, the *force* of which we can estimate by the *effort* we must put forth to resist it. Attenuate any kind of air or gas as we may, its resistance can still be made apparent by the like communication of its own motion to solid bodies. Thus, in Mr. Crookes's wonderful radiometer, a set of vanes, poised on a pivot within a globe of glass exhausted to *a millionth* of its ordinary gaseous contents, is whirled round by the movement excited in the molecules of that residual millionth, either by the heat of the radiant beam falling on the surface of the globe or by the passage of an electric current across its interior; and the mechanical force required to impart that motion can be measured with precision, by bringing it into comparison with some other force (as that of gravity) of which we can take immediate cognizance. And thus, as Herbert Spencer remarks, by the decomposition of our knowledge of any form of matter into simpler and simpler components, we must come at last to the simplest, to the ultimate material, to the substratum; and this we find in the *impression of resistance* we receive through what we may call our "force-sense."*

* Herbert Spencer considers the congnition of resistance to be essentially derived from the sense of muscular tension. I have already expressed my reason for now dissenting from this view, which I myself formerly held.

Such being the teachings alike of general and of scientific experience, I can not but feel surprised that any persons claiming the title of philosophers should affirm that we *know* nothing except matter and motion, and that force is a creation of our own imagination. One might suppose such persons to be either destitute of the "force-sense," or to have based their philosophical system upon the movements of the heavenly bodies which they can only *see*, instead of upon those mundane phenomena in the cognition of which they can bring their *hands* to the assistance of their eyes. How essential this assistance is to the formation of correct conceptions of the solid forms and relative positions of the objects around us is known to every one who has studied the physiology of the senses. Should we not think it absurd on the part of any one who possesses in the use of his hands the means of detecting the error of his visual perceptions, if he were to base a superstructure of reasoning—still more to found a whole system of philosophy—upon the latter alone? Yet such appears to me to be the position of those who deny our direct cognition of force.

Let us suppose (if possible) a man who had enjoyed the full use of his eyes, but whose limbs had been completely paralyzed from infancy, looking on at a game of billiards. He would see a succession of motions connected by regular sequence—the motion of the arm of the player, the stroke of the cue, the roll of the ball, its contact with another ball, the movement of the second ball, the change of direction or the entire stop of the first, the rebound of balls from the cushion in altered directions, and so on. And he might frame a statement in "terms of motion" of all that passes before his eyes, thinking this all he can know. But suppose the limbs of such a man to be suddenly endowed with the ordinary powers of sensation and movement; let him take the cue into his hands and himself strike the ball; let him hold his hand on the table so that the rolling ball shall strike it and make him feel its impact; let him hold the second ball and feel the shock imparted to it by the stroke of the first. Can any one deny that he would thus acquire a dynamical conception linking together the whole succession of phenomena, which he was previously quite incapable of forming; that this dynamical conception is quite as directly based upon the experience derived through his "force-sense" as his kinetic expression was upon that derived through his visual sense; and that this cognition of the force producing the motions is, therefore, fully as much entitled to be introduced into a logical doctrine of causation as the visual cognition of the motions themselves? If it be replied that we have no proof that the movement of the ball we strike is produced by the force which we consciously exert in striking it, I simply rejoin that we have as much proof of it as we have of anything which rests upon universal experience, and which we can verify experimentally as often as we choose to try—quite as much as we have of the existence of anything whatever that is external to ourselves.

Let us take, again, the simple case of magnetic attraction. A man who knows nothing of magnetism sees a piece of iron, brought within a certain distance of what looks looks like a horseshoe bar of the same metal, suddenly jump toward its approximated ends; and might, as before, correctly express the fact in "terms of motion." But let him take the piece of iron in his hands, so as to feel the "pull" upon it when brought sufficiently near the magnet, and he then becomes conscious, through his force-sense, of a *power* of which he was before utterly ignorant.

Thus, as it seems to me, an analysis of those *psychical* experiences on which all our cognitions of the *physical* universe around us are really based irresistibly lands us in the conclusion that, as Herbert Spencer expresses it, "All the sensations through which the external world is known to us are explicable by us only as resulting from certain forms of force"; the direct derivation of our conception of force from our own experience of muscular tension (or, as I should myself say, from our own sense of effort) being "a fact which no metaphysical quibbling can set aside." In the words of the able American writer I have already quoted, "The conception of force is one of those universal ideas which belong of necessity to the intellectual furniture of every human mind." By no one has the principle for which I am contending, been more clearly and more authoritatively expressed than by Sir John Herschel, a philosopher who united to his wonderful grasp of Nature-phenomena a profound insight into the action of the mind of man in the interpretation of them:

> Whatever attempts have been made by metaphysical writers to reason away the connection of cause and effect, and fritter it down into the unsatisfactory relation of habitual [unconditional] sequence, it is certain that the conception of some more real and intimate connection is quite as strongly impressed upon the human mind as that of the existence of an external world, the vindication of whose reality has, strange to say, been regarded as an achievement of no common merit in the annals of this branch of philosophy. It is our own immediate consciousness of *effort*, when we exert force to put matter in motion or to oppose and neutralize force, which gives us this internal conviction of *power* and *causation*, so far as it relates to the material world.—(Treatise on "Astronomy" in Lardner's "Cyclopædia," p. 232.)

Man's position as the "interpreter of Nature" may be not inaptly likened (as it seems to me) to that of an intelligent observer of the working of a cotton-factory, with whose mechanical arrangements he is entirely unacquainted, and of whose moving power he knows nothing whatever. He is taken into a vast apartment,* in which he is at first utterly bewildered by the number and variety of the movements going on around him; but, by directing his attention to the several

* In one of the flax-spinning mills belonging to the Marshalls, of Leeds, the whole of the work is done on one floor, covering, I believe, two acres of ground, instead of in the usual building of several stories.

machines, *seriatim*, he is able to arrive at a *classification* of them, according to the *kind of work* which it does. Thus he finds one set *carding* the cotton-wool supplied to it, so that its confused tangle gives place to a parallel laying of the fibers. He would see another taking up the bundles of carded wool, and *drawing* them out (after repeated doublings to secure uniformity) into a long, soft cord. This cord he would then trace into the *roving*-machine, which, by a continuation of the drawing process, further reduces its thickness, at the same time giving it a slight twist to increase its tenacity, so that it admits of being then wound upon bobbins. Thence he would trace the cord into the *spinning*-machine, which at the same time stretches and twists the cord, producing from it a yarn whose fineness might vary considerably in different machines. Finally, he would see the spun yarn carried, some as weft and some as woof, into the *power*-loom, from which it emerges as woven cloth—the final resultant of the whole series of operations.

Concentrating now his attention upon any one of these machines, he studies its wheels, levers, and other moving parts, and tries to comprehend their several actions and the bearing of these upon each other. By long and scrutinizing observation he masters the whole series of sequences, and traces the distribution of motion from a single large axis, through the hundreds (it may be) of separate pieces of the machine directly or indirectly connected with it; and he might thus frame a description of the working of the machine, which might be perfectly correct so far as it goes, and which yet would be defective in one most essential particular—the statement of the *force* or *power* by which it is moved. For, so far as mere visual observation could teach him, the machine might be self-moving; and he might thus attribute to each kind an *inherent power* of carding, roving, drawing, spinning, or weaving, as the case might be.

Carrying his observations further, and noticing that one or another of these machines comes to a standstill, but resumes its motion after an interval, he may include this occasional suspension also in his general expression; but, perplexed by the want of any regularity in its intervals, he will seek some further explanation. Continuing his patient watch, he will see that the stoppage of the machine follows the pulling of a handle by the man in attendance upon it, and that, when the handle is pulled the other way, the machine goes on again; and thus he will be led to introduce a certain position of this handle as one of the antecedent conditions of the machine's action. Still pursuing his inquiries, he finds out that the axes of the several machines are all in mechanical relation with one great longitudinal shaft, being connected with it either by continuous bands passing around pulleys, or by trains of wheelwork; and at last he discovers the important fact that the movement of the handle which stops the machine breaks the continuity of that relation, shifting a strap from a "fast" to a "loose"

pulley, or throwing the wheelwork "out of gear"; while the converse movement, which restores that continuity, is followed by the renewed action of the machine, which goes on until the continuity is again broken. Thus he will be led to regard its maintenance as essential to the working of the machine; but nothing that he has yet learned explains to him *why* it is essential. He has only got at the *material collocation* which his educated vision enables him to recognize; and, for anything he knows to the contrary, the change in that collocation may be *in itself* adequate to determine the result.

But let him lay hold of the band which stretches between the main shaft and the axis of one machine, or attempt to stay with his hand the rotation of the train of wheels which connects it with another—he then at once becomes conscious, through his "force-sense," of the *power* which the band or the wheelwork is the instrument of conveying; and as he finds that the "pull" upon his hand is just the same whether the machine is in motion or not, provided that the band or wheel remains in mechanical connection with the main shaft, he comes to the conviction that the *source* of the power is in the shaft, and that, so far from any one of the machines having an inherent power of movement, its motion entirely depends upon the force supplied to it from the shaft. And when, under the guidance of this conception, he again examines the *working* of the several kinds of machine, he finds that, while the *power* is the same for all, the diversity in their respective products is traceable to the diversity in their construction—that is, to the *material collocations* through which the one moving force exerts itself in action.

But, having thus acquired the notion of *moving power*, and having satisfied himself of the derivation of the force that gives motion to each of the entire aggregate of machines, from one main shaft, our inquirer finds himself again posed. Has this shaft itself an inherent power of motion; or does it derive that power from any ulterior source? He sees the shaft apparently terminate in the two end-walls of the building; and, finding no evidence of its connection with anything else, he may feel himself drawn toward the conclusion that it moves *of itself*—that is, by the "potency" of its own material constitution. But, before adopting this *rationale*, he sees all the machines stop at once, and finds that the shaft also has ceased to revolve. Here is a new and startling phenomenon. After pondering on it for an hour, and carefully looking out for an explanation, he sees the shaft and its connected machines resume their motion, and yet is certain that no agency visible to him has had any concern in that renewal. By continued watching, he finds this suspension and renewal to be periodical, so that he can frame a law that shall express them in terms of *time*. Thus he might give a complete *phenomenal* account of the action of the shaft which should be perfectly consistent with the assumption of its "inherent potency," and which might be sufficiently satisfactory to his mind to justify him in believing that there is no more to be learned

about it. But, not wishing to leave anything uninvestigated, he goes round to *the other side of the wall.* There he finds that one end of the shaft comes through it, and is in mechanical connection with either a steam-engine or a water-wheel; and, by watching what occurs when its motion is checked and renewed, he sees that the engineer shuts off, or turns on, either the steam generated in the boiler of the steam-engine, or the descending water whose motion drives the wheel.

I shall not weary the patience of such readers as may have followed me thus far, by tracing out in like detail the further steps of the inquiry, but shall land them in the final conclusion now accepted by every man of science—that the power exerted in both these cases is drawn from solar radiation: the fall of the water which gives motion to the water-wheel being merely the return of that which has been pumped up as vapor by the sun's heat; while the combustion of coal from which steam-power is derived reproduces, as active force, or "energy," the sunshine that exerted itself during the Carboniferous period in dissociating carbonic acid and water into the hydrocarbons of coal and the oxygen of the atmosphere, whose recombination gives forth heat and light. And, if we look still further back for the source of the sun's radiant energy, we should find it, perhaps, in the progressive consolidation of the primeval "fire-mist"—nebular matter.

But whence nebular matter? And whence the force which draws its particles together, and which manifests itself as light and heat during their consolidation? Here we come to a wall, to the other side of which we seem at present to have no access.

But *is* there no other side? Does not the whole course of the preceding inquiry show the unsatisfaction (if I may revive an obsolete word) of resting in any inherent "potency" of matter as the *ultima ratio* of the existing cosmos? If we think the man foolish who supposes the main shaft of a cotton-mill to turn *of itself*, merely because he sees it apparently end in a wall which conceals from him the source of its motive power, are we not really chargeable with the like folly if we attribute self-motion to the ultimate molecules of matter, merely because the power that moves them is hid from our sight? The mere physicist may see no possible way further. But there is a philosophy which has fully as true and as broad a basis in man's psychical experience as can be claimed for the fabric of physical science; and, in the admirable words of the great master I have already quoted (Sir John Herschel, in his "Familiar Lectures on Scientific Subjects," p. 460), I shall sum up an argument which this paper is intended rather to illustrate and enforce by an appeal to the familiar facts of consciousness than to present in strict logical form:

In the *mental sense of effort*, clear to the apprehension of every one who has ever performed a voluntary act, which is present at the instant when the determination to do a thing is carried out into the act of doing it, we have a consciousness of immediate and personal causation which can not be disputed

or ignored. And, when we see the same kind of act performed by another, we never hesitate in assuming for him that consciousness which we recognize in ourselves; and in this case we can verify our conclusion by oral communication. . . . In the only case in which we are admitted into any personal knowledge of the origin of force, we find it connected (possibly by intermediate links untraceable by our faculties, yet indisputably *connected*) with volition, and, by inevitable consequence, with *motive*, with *intellect*, and with all those attributes of mind in which personality consists.

As a physiologist, I most fully recognize the fact that the physical force exerted by the body of man is not generated *de novo* by his will, but is derived from the oxidation of the constituents of his food. But holding it as equally certain, because the fact is capable of verification by every one as often as he chooses to make the experiment, that, in the performance of every volitional movement, that physical force is put in action, directed, and controlled by the individual personality or *ego*, I deem it just as absurd and illogical to affirm that there is no place for a God in nature, originating, directing, and controlling its forces by his will, as it would be to assert that there is no place in man's body for his conscious mind.—*Modern Review.*

NEW VIEWS OF ANIMAL TRANSFORMATIONS.*

By EDMOND PERRIER.

ONE of the results of teaching at the Museum is, that it always has considerable influence upon the teachers themselves. Forced by the nature of this institution to keep himself constantly acquainted with what is known and what is sought, with what is definitely acquired to science, and with the object of aspiration, obliged to coördinate recent with preceding discoveries, to test theories, to bind together the new material continually accumulating about the stones forming the vast edifice of science, the professor sees the lines of this structure slowly modified, he himself contributing to this result, and sometimes ends his career under the sway of other ideas than those which at first inspired him.

I confess that this has been my experience. Last year I began a series of investigations upon transformation. I had not taken sides upon this doctrine. If some general ideas had drawn me toward it, I had ever present the reiterated objections of the most illustrious French naturalists, among whom were the men I most love and venerate. But, as I proceeded with my lectures, it seemed to me that these objections were not insurmountable, that they did not touch the foundations of

* Introductory lecture to a course on Zoölogy at the Museum of Natural History in Paris, delivered March, 1879.

the doctrine, and belonged rather to the way of conceiving that the evolution of organisms has taken place. Looking not for differences but relationships among organisms, I thought I saw that a simple and general law had governed their formation, that they were derived one from another by a constant procedure, and I found myself adding further arguments to the theory of the genealogical origin of species. The law which I now have to put forward may be called the law of *association;* and the process by which it works, *the transformation of societies into individuals.*

When we have proved that all living beings are composed of microscopic corpuscles more or less alike, when we see such corpuscles capable of leading an independent life constituting by themselves the simplest organisms, it occurs to us to compare the higher animals and vegetables to vast associations of distinct individuals, each represented by one of these corpuscles or cells. In the same animal the cells assume many different forms, having different physiological properties. These forms and properties are not modified by the vicinity of different cells. Within the organism each cell lives as if it were alone. If it were possible to isolate a cell of the human body and surround it by normal nutritive material, it would continue to live, to develop and reproduce itself, and carry on all its physiological functions exactly as before. Further, in the organism itself, the life of each cell is so independent of that of its neighbors, that we may kill all the cells of one kind without injuring the others. Claude Bernard has proved that curare poisons the elements that terminate the motor nerves, thus abolishing all movement without injuring any other part of the system and leaving sensation intact. These researches led him to the principle of the *independence of the anatomical elements.* Not only are the elementary individuals of organisms sometimes very dissimilar, but they preserve their personality, live their own way, and keep up with their fellow citizens the relations of good neighborhood. We may compare an animal or plant to a populous town, where each person practices a particular industry on his own account, and yet helps the general prosperity through the activity of exchange. In high organisms, a special corporation in ceaseless movement is the medium of these exchanges. The blood-globules are true traders, taking along in the liquid where they swim the complex merchandise in which they deal.

Just as we had employed all the comparisons that pedigree furnishes to express the likenesses among organisms before supposing them really to be blood relations, so we have compared organisms to societies and societies to organisms, all the while regarding these comparisons as mere fancies. On the contrary, in the last year, we have reached the conclusion that *association* has played an important if not exclusive part in the development of organs. We find convincing proof of this in the history of Polyps and of Worms. The connection

of Worms with the Articulata is apparent to every one, and we already see how these same Worms are related to Mollusca and Vertebrata. The theory, therefore, extends to the entire animal kingdom.

Now, what do we mean by association? When we say that animal organisms have been in great part produced by the transformation of animal societies into individuals, what do we mean by the term *society?* Are all societies in the way to become individuals? Many animals associate together, and their societies are sometimes admirably governed. The social manners of dogs, antelopes, beavers, and many birds are well known, while the complex and perfectly coördinated operations of societies of bees, ants, termites, are the admiration of the world. Do such societies ever become individuals? Certainly not. But there exist other animal societies in which the relations are closer—where the individuals are not only in immediate contact but in continuity of tissue with their neighbors. These societies are called colonies, but the individuals that compose them are not always indissolubly united together. They can separate from their companions, and live a long time and affirm their independence by forming new colonies. In the same zoölogical group of neighboring species, we find some individuals that always live solitary and others always associated, as for example the specially remarkable group of Polyps or Acalepha.

One species of this group, the brown Hydra (*Hydra fusca*), is common in stagnant waters and even in small garden basins. It has always excited the interest of naturalists and philosophers since Trembly made known its marvelous faculties. These Hydras ordinarily live solitary; but frequently the larger individuals are seen carrying smaller ones on the walls of their bodies. In a captured Hydra we can follow their development step by step. They are at first simple swell-

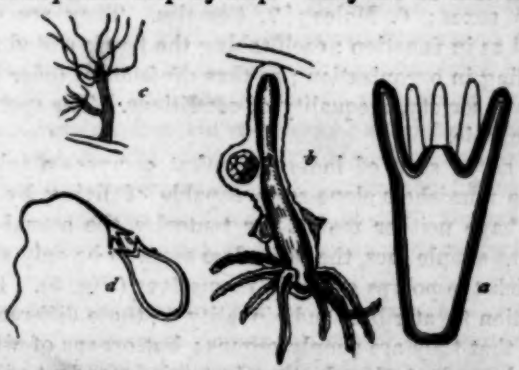

FIG. 1.—*a*, diagrammatic section of Hydra; *b*, *Hydra viridis*, showing swellings in the body-wall; *c*, *Hydra vulgaris*, with an undetached bud enlarged; *d*, thread-cell of the Hydra, greatly magnified.

ings, in the center of which there is a prolongment of the cavity of the mother's body. These swellings enlarge and soon put out tentacles, and a mouth opens in the midst of the crown formed by them.

The young Hydra, like its mother, is a simple sac with its wall composed of a double layer of cells, the cavity or stomach communicating directly with the stomach of the mother, so that the contractions of the body carry all the food taken by one into the stomach of the other, and inversely (Fig. 1). The parent and child live awhile in this way, but, whenever the latter has reached a certain size, it is detached and fixes itself on some near object, where it hunts on its own account. Soon the parent and offspring are indistinguishable, and during the summer they never cease to produce new Hydras. But, sometimes, in fertile waters rich in game, each Hydra retains its progeny, the little ones grow and produce new Hydras in their turn, and thus a new colony is founded. Trembly kept a long time a Hydra that carried twenty-two young ones of four different generations—a living genealogical tree.

That which is accidental in the common Hydra is quite normal with another fresh-water species, the *Cordylophora lacustris*, and in most marine Hydroids, in which the colonies often consist of innumerable individuals. But then new phenomena are seen. The social life becomes complicated, and a true *division of labor* occurs among the members of the same colony. At first all were alike, performing the same functions in the same manner. Specialization soon begins: some hunt, others digest, others reproduce; so that individuals that at first had no need of each other and lived united only in a careless way, become reciprocally necessary; the society thus acquires coherence and solidarity. In the Hydractinia we count not less than seven sorts of individuals: 1. Nourishers or gasterozoids; 2. Prehensers or dactylozoids, provided with bunches of stinging capsules; 3. Dactylozoids without stinging capsules; 4. Defenders; 5. Reproducers of individuals of both sexes; 6. Males; 7. Females. They are different in shape as well as in function; each taking the figure suited to its work, rising or falling in organization; so that *division of labor* brings with it, as in human society, inequality of conditions. The species thus become polymorphic.

Of these seven sorts of individuals that compose a colony of Hydractinia, the nourishers alone seem capable of living by themselves. The others have neither mouth nor tentacles, the sexual individuals are reduced to simple sacs, the defenders seem to be only sharp spines, between which the polyps can hide themselves (Fig. 5). It may seem an exaggeration to attribute individuality to these different parts. It may be said that they are simply organs; but organs of what? They are just as independent of each other, just as independent of the nourishers, as the latter can be of one another. They are, then, not organs of those Polyps. Can they be organs of the colony? It is already understood that the colony has the character of an individual, and the transformation we seek to demonstrate is admitted. But how can a colony acquire organs? Whence can they arise except from a transformation

of the individuals which compose it? We have no need of hypothesis, however, to demonstrate that these *colonial organs* are the equivalents of true individuals. The buds that give birth to the different sorts of individuals in a colony of Hydractinia all grow alike, and re-

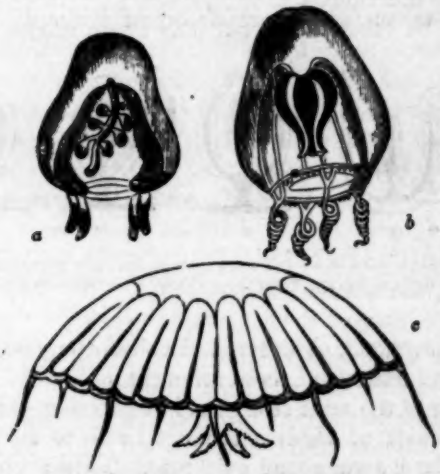

FIG. 2.—NAKED-EYED MEDUSÆ.

main alike for a long time. This is the first presumption in favor of their equivalence. But in the allied type, *Podocoryne*, we see the humble sac, which represents the sexual individual, replaced by a being more active, more elegant, much more elevated than the Hydra itself, by a transparent medusa, which is detached when it reaches maturity and swims actively in the water, the colony suffering no inconvenience from the change (Fig. 2). These medusæ constitute the most general

FIG. 3.—*a*, fragment of *Cordylophora lacustris* slightly enlarged; *b*, same, showing gonangium; *c*, portion of *Syncoryne sarsii*, with medusiform Zoöids budding between the tentacles.

form of the sexual individuals in the group of Hydroid Polyps, but they are very polymorphic. Their form is modified from one species

to another, and arrested at all stages of development. Sometimes, although completely formed, they resign their freedom and end their existence in the colony where they were born.

In one group of Polyps the Medusæ associate themselves with the reproductive individuals to form a new unit—a small, distinct colony, that might be taken for a peculiar organ curiously analogous to a

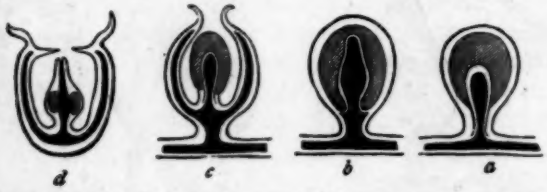

FIG. 4.—GENERATIVE BUDS OR GONOPHORES OF THE *Hydrozoa* DIAGRAMMATICALLY REPRESENTED. *a*, simple gonophore; *c*, gonophore which has the structure of a Medusa (medusoid), but is not detached; *d*, free medusiform gonophore.

flower—with a separate chamber, and called the *gonangium* (Figs. 3 and 4). A step further and these strongly individualized Medusæ are seen descending to the rank of organs in more complex colonies.

All the colonies of Hydras are not fixed to submarine objects. Some of them lead a vagabond existence. They are often taken, not without reason, for simple animals analogous to the Medusæ, and called

FIG. 5.—OCEANIC HYDROZOA, SHOWING THE SPECIALIZATION OF PARTS. 2, Siphonophore; *n*, swimming-bells; *p*, alimentary region; *t*, tentacles; 3, diagram of the composite body of one of the Siphonifera: *a a*, swimming-bells; *d*, spines or defensive individuals; *f*, digester.

Siphonophores (Fig. 5). They sometimes attain a large size; and the variety and profusion of the parts which compose them, as well as the brilliancy of color and incomparable beauty of their forms, have made them subjects of the profound admiration of naturalists as well as sailors (Figs. 6 and 7). Each one of these parts is the equivalent of a

Hydra or of a Medusa. In one *Agalma* we find, as in the Hydractinia, nourishers supplied with one long tentacle, of which a single touch produces a severe burning sensation, a sort of fish-line, which in large species is capable of capturing fishes. Besides the nourishers,

FIG. 6.—HIDDEN-EYED MEDUSA.

FIG. 7.—GONOPHORE OF ONE OF THE *Campanularida*.

are found individuals without a mouth, which are only reproducers, in the neighborhood of which are sexual individuals resembling Medusæ in form. All these individuals are fixed upon a common axis, which floats like a serpent in the water, where it is sustained by an air-vessel forming its superior extremity. Two series of sterile Medusæ appear underneath this bell, a gang of oarsmen (physales), to which the colony abandons the care of locomotion.

These various parts are in all respects too much like the Hydras and Medusæ for us to refuse them the character of individuals; the Agalma and other Siphoniferæ are true societies or colonies. But here most of the individuals can not separate themselves without danger of death; and, in certain cases, they all coördinate their movements that the colony may perform certain acts. For example, in the Portuguese men-of-war (Fig. 8) the physales frequently change their course, and then all the individuals of the colony concur in the operation. They have, then, a will which controls them—a will that can find the grounds of its decisions only in a sort of social consciousness, elevating the colony to the rank of a psychological unit. Composed of individuals each of which is equivalent to those Hydras or Medusæ that live free and isolated and sufficient for themselves, every Siphonophore must still be considered in its turn as a single animal

—a true individual of a higher order. Here the transformation of the colony to an individual is manifest. The Siphonophore is an animal with organs made up of distinct animals, each having a particular function. Elsewhere we see these animal organs become less and less independent. They come together and arrange themselves around a central axis which predominates, and end by forming a being like the Porpita or Velelle, which, but for the study of neighboring types, would not be thought of as a decomposable animal.

FIG. 8.—*a*, Portuguese man-of-war (after Huxley); *b*, *Velella vulgaris* (after Gosse).

At the present time most people consider Sea-anemones (Fig. 9) and Polyps, of the madrepores, and coral, as simple organisms—primitive individuals; while to us their origin is the same as that of *Porpitæ* and *Velellæ*—the union of three sorts of Hydroid Polyps. The admirable researches of Moseley on the Polyps of the family of *Stylasteridæ* furnish proof of this. If we consider only their calcareous parts, all these beings seem to be true Madrepores. The first doubt concerning their true nature was raised by Agassiz, with reference to the Millepores.

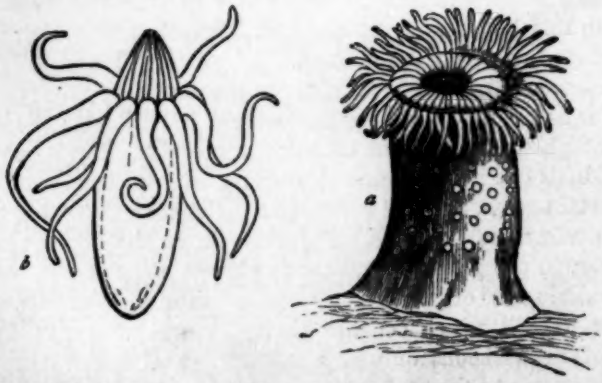

FIG. 9.—SEA-ANEMONES. *a*, *Actinia rosea*; *b*, *Arachnactis albida* (after Gosse).

Between a Coralarian and a Hydroid Polyp the difference is considerable. One is a simple sac with tentacles, usually solid appendages

of the wall of the body, that vary in number with the species, or sometimes with individuals, but are constant for each during the great part of its life. The other is formed of a stomach-like sac, open at bottom, around which are hollow tentacles, which often increase in number with the age of the Polyp (Fig. 10). These tentacles, which are free at their extremities, and united at their bases to form the wall

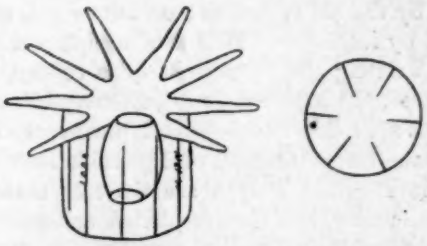

FIG. 10.—DIAGRAMMATIC FIGURE OF SEA-ANEMONE.

of the Polyp's body, open inward like the stomachal sac into a great cavity, the circumference of which is divided into cells by the soldered walls of two neighboring tentacles. On the partitions of these cells, and so within the body, the reproductive apparatus is developed; while in Hydroid Polyps it is generally on the exterior in the form of a bud. This type of structure is much more complex than that of the Hydroid Polyp, which is well represented by the Stylasteridæ. In their colonies we find the polymorphism of the Hydroida, and also the nourishers, purveyors, and reproducers. Among the *Spinipora*, *Sporadopora*, *Pliobothrius*, *Errina*, these different sorts of individuals are perfectly independent of each other: a simple vascular network distributes among them the food seized by the hunters and elaborated by the nourishers.

But with the Millipores the nourishers are the most important members of the colony, as they prepare all the nourishment, drawing around them the hunters and reproducers, but without establishing any more intimate relations. With the *Astylus*, the *Stylaster*, the *Cryptohelia*, this movement of concentration around the nourishers becomes pronounced; a space forms underneath; the tentacles, rendered useless by the neighborhood of the hunters, disappear, and nothing remains but a digestive sac around which the hunters perform functions exactly like those of the tentacles of a Coralarian Polyp. Each system has now a decided individuality. Another step, and the hunters, from being distinct throughout their whole length, grow together at the base and interlace with the digesters, and the reproducers follow in this movement. These different parts are, thenceforward, too near together to require a special vascular system; the vessels which unite them are simple perforations of their wall which open in the space just below the digesters, and into which the reproducers pene-

trate also. But this whole the most experienced naturalist could not distinguish from a Coralarian Polyp. Among Coral Polyps the individual is, then, an association of parts of different form, of which each is equivalent to a Hydroid Polyp.

A Coral Polyp with twelve tentacles is the sum of a considerable number of Hydroid Polyps—one digester, twelve hunters, and a variable number of reproducers. It is formed by the aid of Hydroid Polyps, as flowers by the aid of leaves; or, better yet, as the composite flower is formed by its florets. It is produced in the same way as the Porpita or the Velella; the *formation of a colony*, the *division of physiological labor*, the *appearance of polymorphism*, and the *concentration of the parts so elaborated*—such is the succession of phenomena which marks the transformation of Hydroida into Velellæ and Sea-Anemones. The Hydroid Polyps are the raw materials which are brought into the factory, and then fashioned and gathered together to form higher individualities.

While these morphological phenomena are taking place, others are also occurring in a physiological order. At first the associated individuals have nothing in common except nourishment, which all are capable of elaborating, but which passes from one to another so that all are equal partakers. It is just here that consolidation begins, but each polyp still preserves his personality. He has his own will, and does not share his sensations with his neighbors; we can wound or even remove one without disturbing the rest. But, in proportion as the colony becomes more coherent, sensations extend farther and farther around the polyp that experiences them. Soon all the individuals

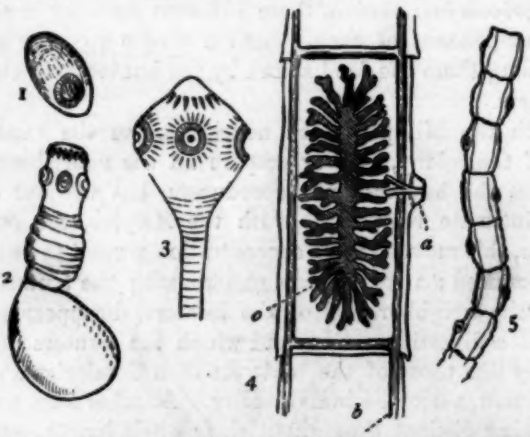

FIG. 11.—MORPHOLOGY OF TAPE-WORM. 5, fragment of tape-worm showing the joints; 4, single joint enlarged showing ovary, *o*, generative pore, *a*, and canals, *b*; 3, head of tape-worm.

are conscious of that which happens to any one of them, thus forming a colonial consciousness above that of the individual, and finally a single will bends all the special wills to its bidding. A new individ-

ual is now definitely constituted. Is not this the same law which presides over the transformation of savages into civilized people? Have not nations, corporations even, a consciousness and will? Do they not form great units which we designate by one word in current language?

The transformations we have followed step by step in the class of Polyps are not restricted to these animals. It is easy to show how

Fig. 12.—Trematode Worm.

simple forms are again associated, in the group of Worms, to obtain the more complex forms. We find here the same laws as in studying the Polyps. Long ago, Van Beneden, Professor at the Catholic University of Louvain, affirmed that each joint of a tape-worm (Fig. 11) was

Fig. 13.—Somites of Insect.

the equivalent of a Trematode worm (Fig. 12); and Douve still earlier taught that the rings of a worm, or of an insect, were considered

by naturalists as equal units, formed of the same parts, having each a real individuality. The name Somites, which has been given them, shows the tendency to consider them as true elementary animals associated in colonies (Figs. 13 and 14). The power possessed by the segments of certain worms to individualize themselves and form new colonies is strong evidence in favor of this view. Polymorphism and the concentration of parts explain how a *Peripatus* or a *Myriapod* can

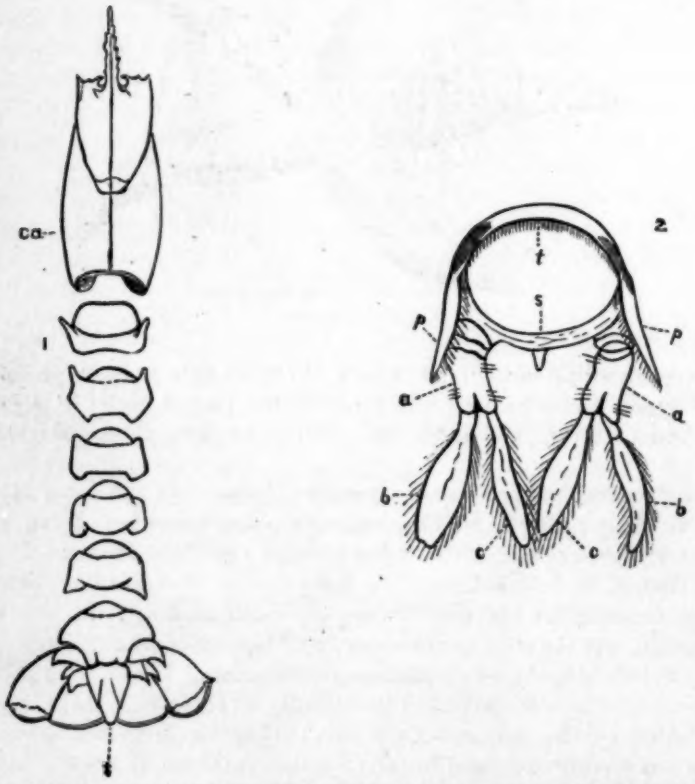

FIG. 14.—LOBSTER WITH THE SOMITES SEPARATED FROM EACH OTHER, THE APPENDAGES BEING ALL REMOVED EXCEPT THE TERMINAL SWIMMERETS. *ca*, carapace; *t*, telson; 2, third abdominal somite with its appendages.

become a spider or an insect, how different Crustacea arise from a common stem, how from another form of colony have arisen all the Annelida. It has been often said that Echinoderms, Star-fishes, Ophiurans, were only colonies united by the head (Fig. 15). They are, at least, all colonies, but of a special nature.

Can we say as much of the Mollusca and Vertebrata, all the parts of which are so closely united, and which are the giants of creation? Are there simple forms of association which can explain the marvelous organization of these superior types of creation—as we have explained the Siphoniferæ, Coral Polyps, Echinoderms, and Arthropoda?

This is the question for our present course of lectures ; but, whatever the result of our inquiries, it will not invalidate the generality of the principle of *association*. If, contrary to our past opinions, these higher beings are not simple individuals, we must compare them with

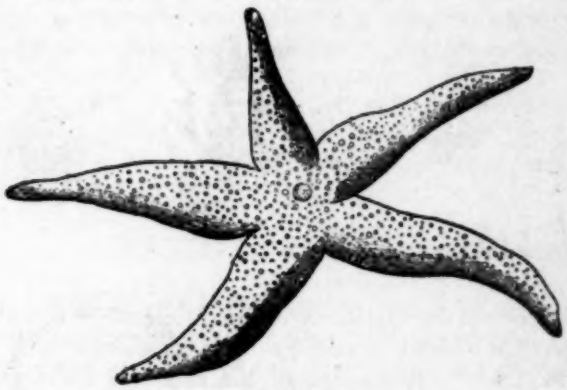

FIG. 15.—STAR-FISH.

those primordial individuals which by combination have produced other types, and which are still found at the base of each of the great divisions of the animal kingdom. Now, how have these individuals arisen ?

The Hydras and analogous organisms reply. We can cut a Hydra into as many pieces as we like, and each piece, instead of dying, continues to develop and ends by becoming a complete Hydra. It follows that these different parts are independent of each other, like the polyps forming the lowest colonies. Each cell of the Hydra is a true individual, and the Hydras are a colony of these monocellular individuals as the Siphonophores themselves are colonies of Hydras. Aptitude to social life is communicated by heredity to these cells, as it is communicated to the polyps. Each cell, each polyp, detached from the colony, is a copy of it, and his after-development tends always toward its formation. At first all the members of a colony are equally apt to reproduce ; then this function is localized like the others, and pertains to some individuals, or some parts, while sexual reproduction becomes more and more important. When the society reaches a certain degree of coherence, these different parts cease to live independently of the others, and can not be separated without danger of dying.

We see still more clearly in the Sponges their colonial nature. The spongarian individual is formed of two sorts of cellular individuals, the amœba and infusorial flagellifere, of which we find analogues living, at liberty and in isolation (Fig. 16). The flagelliferous cells of sponges present exceptional features ; they are provided with a nucleus and contractile vesicle, and their unique flagellum is surrounded by a mem-

branous collarette in the form of a funnel. All these characters are found in the *Codosigæ*, monocellular Infusoria, always living isolated, and are to the sponges what the Hydras are to the Siphonifera and Coral Polyps. In the *Anthophysæ* these cellules live in colonies, but are yet all alike. Let polymorphism step in. Let some of the asso-

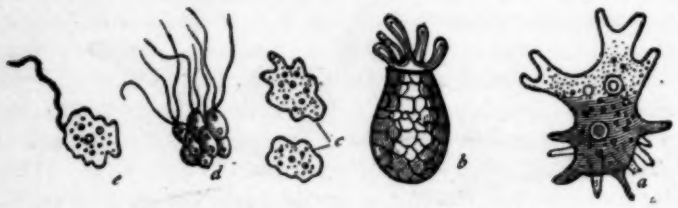

FIG. 16.—*a* and *b*, Amœbæ; *c*, *d*, *e*, sponge particles.

ciated cells preserve the flagelliferous form, while others become amœbæ, a transformation which is possible, since it constitutes one of the most frequent modes of reproduction of the amœboid Infusoria, and the *Anthophysa* is transformed into a sponge. The process is always the same, whatever the nature of the assembled materials. Cells or polyps, it always submits to the same elaboration in developing new individuals. The cells, once assembled in the organism, yield easily to the changes required by the division of physiological labor, and form various organs, although these organs never become true individuals. If the individuals of a colony often descend to the state of organs, we must not conclude that the organs of an animal are always individuals that have lost their autonomy; but the animal to which they belong, though it may never have been an assemblage of individualities intermediate between its own and that of cells, is not less a colony of the latter subjected to the laws of evolution of all the others. Thus even if we can not prove that Vertebrates and Mollusks have resulted from the fusion of more simple beings that have lived an independent life, they are still colonies of cells, and the *law of association* has consequently lost none of its generality.

It remains the fundamental law of development in the animal kingdom, comprehending and controlling those *laws of growth*, of *organic repetition*, of *economy*, which have been long accepted by physiologists, explaining hitherto mysterious *homologies* between different parts of the body, or between different organs of the same animal; embracing in one circle all the forms of asexual generation, which are its most powerful means of creation. Resting upon the law *of the division of physiological work*, the importance of which was first demonstrated by Milne-Edwards, and upon that of *polymorphism*, which without it have only a limited and indefinite meaning, consequent on the law of division of protoplasmic masses, it has been the great producer of organization, and establishes a new link between

sociology and the branches of biology that are occupied with the constitution and functions of organisms.

We now reach the ultimate elements of living bodies, the material which has served to make the most simple beings, and we ask, What is its origin? Here we are in the presence of unity; there is no longer any question of association. Most living cells are composed of four parts—a membranous envelope, a contained fluid in which is a special globule, and the nucleus, containing the nucleolus. Of these four parts only one, the contained semi-fluid, perfectly limpid or finely granular, the *protoplasm*, is indispensable. It is in this strange substance that life, which needs no other apparatus to manifest itself, resides. Those remarkable beings, the Monera, are formed of it alone. They are simple, homogeneous clots of a limpid jelly like the white of egg. This jelly has the power of movement, captures animals, digests and assimilates them, grows, and, when it has attained a certain size, divides into two or several masses, that begin anew the life of their mother, and divide like her when they have reached a certain size.

This faculty of division is an important property of protoplasm, because it governs all organic evolution. A protoplasmic mass can not exceed a determinate size. When it reaches this size, a partition forms, and, as its mass is perfectly homogeneous, as it is constantly traversed by currents that completely mingle its substance, all the resulting fragments possess the acquired or hereditary properties of the protoplasmic mass from which they came. This explains all the phenomena of *heredity*, by means of which each being transmits to its progeny, even in the case of sexual generation, all its specific and part of its personal characters.

From this incapacity of protoplasmic masses to exceed a certain length, it follows that all beings that are larger must be formed of several distinct masses of protoplasm—in a word, are colonies. So the generality of the law of association appears as a consequence of one of the fundamental properties of protoplasm. It constantly decomposes itself into distinct masses. These separate masses are modified, each in a particular fashion, under the influence of external agents. Hence the wonderful variety of nature is an immediate consequence of the law of association, of the necessity imposed upon protoplasm to separate into small distinct individualities.

What, then, can be the nature of protoplasm? Struck by its homogeneity, the identity of the elements that compose it with those that form albuminoid substances, it has been taken for a mere chemical compound, and it has been boldly asked if it is not possible to produce it artificially; if man has not power to relight the torch of Prometheus and create life at will. This question, I believe, has been asked in consequence of a strange confusion of words. If it is true that the substances that form living matter are the same as those that enter

into certain chemical compounds, we can not infer from this that protoplasm is one of these compounds. What characterizes a chemical compound is fixity of composition. But protoplasm changes incessantly, without modifying any of its fundamental properties. New substances are constantly entering into its mass while others are leaving it. Protoplasm is perpetually decomposing and recomposing itself. It is this, and not its chemical composition, that characterizes it. It is always in movement, and motion characterizes life.

Life is, then, only a combination of movements, or, if you please, a mode of movement of which certain substances are alone capable, and which is not without analogy with the whirling movements to which eminent physicists attribute the properties of chemical atoms. We might pursue this comparison between atoms and protoplasms, and use it to show that the latter must have been formed originally in the greatest possible number; that we seem to be powerless to reproduce them; that they appeared with a train of properties which have controlled their subsequent destiny; and that they had from the first the individuality we see in them at the present day.

THE DUTY OF ENJOYMENT.

TO say that we are under a moral obligation to enjoy ourselves would be, in the opinion of most persons, to utter an unmeaning paradox. It is commonly supposed that the natural instinct for pleasure can take care of itself without any reënforcement from a sense of duty. More than this, our habits of thought instinctively lead us to set duty in antagonism to pleasure, so that to talk of a duty of enjoyment sounds self-contradictory. Many influences have combined in the past history of our race to produce this conception of the relation of pleasure and duty. Unless this idea had been developed and fixed in the human mind, it is difficult to see how the moral progress already attained would have been possible. Even that extreme form of this doctrine of the antagonism of pleasure and duty involved in the ascetic renunciation of all enjoyment as sinful was doubtless a useful and necessary belief in certain stages of social evolution. But it may be that this conception of pleasure has now lost its utility, and will have to be displaced by a view of life which sets a positive moral value on enjoyment. The epicurean theory that all good resolves itself into pleasure has long been before the world, and has won many adherents. Since the revival of letters many writers have contended warmly against the mediæval disparagement of pleasure. Of late years a number of writers with a keen appreciation of the æsthetic resources at our command have in beautiful and alluring language held up a

refined hedonistic ideal of life, according to which all irksome sense of duty will melt away in a rational cultivation of choice delights; and now a leading philosopher has added the weight of his name to this tendency of ethical thought by distinctly enforcing the duty of compassing a pleasurable existence, a duty which he thinks to be sadly neglected in these days.

The arguments put forth by Mr. Herbert Spencer in his latest volume, "The Data of Ethics," in support of the proposition that the cultivation of pleasurable consciousness is a prime duty of life, will be sure to excite a good deal of attention. His fundamental idea is that pleasure is good, because it is the accompaniment and mark of a healthy exercise of a useful or life-preserving function. Pleasures and pains have been attached to actions beneficial and injurious to the organism by the working of the laws of evolution. Since it is an inevitable law of our mental nature that we should seek pleasure, and since, too, it is a condition of self-preservation and survival in the struggle for existence that our actions should tend to organic efficiency, it follows that the coincidence of pleasurable and life-serving activities must from the first have been a necessary condition of permanent existence. Mr. Spencer thinks that people have altogether overlooked this truth. Even moralists who might be supposed to know better have, he conceives, failed to recognize the function of pleasurable feelings as guides to sound living. Men are excused, if not commended, when, in pursuit of some worthy distant object, they pay no heed to the bodily pain which should have told them that they were not fulfilling the first conditions of all efficient action. Again, pleasure is to be recommended as directly effecting an increase of energy, bodily and mental, as raising "the tide of life"; yet moralists have altogether forgotten this when pronouncing their sweeping condemnations of pleasure as evil, or at least as of no moral value. Mr. Spencer appears to feel a genuine abhorrence of the ascetic conception of pleasure, for he speaks of the "tacit assumption, common to pagan stoics and Christian ascetics, that we are so diabolically organized that pleasures are injurious and pains beneficial." He does not attempt, as an evolutionist very well might have done, to account for the genesis and survival of the ascetic doctrine. Later on he dwells at some length on the importance of a due pursuit of individual enjoyment as a preliminary to an effective rendering of services to others. In this way he would erect the study of pleasure into a double obligation—a duty to one's self and to others.

Most readers will allow that there is much force in Mr. Spencer's reasonings. It may be doubted, however, whether the common neglect of pleasure as a good thing proceeds as much from lingering ascetic ideas as he supposes. In their severer form these ideas are confined to a few religious sects, and even among them they are not now enforced so rigorously as formerly. It is to be added that the

modes of enjoyment more especially disparaged in this ascetic teaching are of very questionable value. It may be doubted, for example, whether much dancing, carried on into the small hours of the morning, or much frequenting of hot and badly ventilated theatres, conduces to a really pleasurable and efficient life. On the other hand, it deserves to be remembered, perhaps, that society distinctly puts its mark of approval on enjoyment by actually imposing the duty of pleasure-seeking on its individual subjects. Many a delicate woman will attend the social gayeties of the season because she is expected to enjoy herself in this way; and many a busy man will take his month or six weeks' holiday at a fashionable pleasure resort, not because he desires the kind of enjoyment offered, or even expects to realize it, but simply because society tells him to act thus. What makes people neglect pleasure much more than any form of ascetic prohibition is, we suspect, personal indifference arising from inattention and preoccupation. More particularly in our busy age, men are very apt to be absorbed in some exciting pursuit, so as to overlook the pleasurable resources of life. Often this engrossing pursuit, though entered on at first from a motive of pleasure, ceases to bring any appreciable enjoyment, and thus the whole life becomes to a large extent robbed of its proper emotional hue. Nor is this narrow and unreflecting disposition of opportunities and energies simply a loss of so much enjoyment. It commonly results in the accumulation of a large mass of pain. The non-satisfaction of natural tastes and impulses pretty certainly brings a vague sense of something wanting—a dreary feeling which depresses the mental tone and throws a gloom on life. Add to this that the state of mental absorption in some one line of activity is highly favorable to a neglect of all the many little circumstances which must coöperate in sustaining health. The first indication of this inattention to health is probably a development of abnormal nervous irritability. The temper is ruffled; sources of annoyance multiply, while those of gratification decrease in the same ratio. The full development of this change is seen in a morose view of life, which has the same practical results as a professed asceticism. There is a growing disposition to dwell on vexatious elements of experience, to nurse a sense of injury, and a corresponding disinclination to seek enjoyment, or even to accept it, when close at hand.

It seems to us that this neglect of the conditions of a full and pleasurable life is, as Mr. Spencer suggests, a thing to be severely deprecated on moral grounds. For there is no doubt that it leads in a number of ways to the infliction of suffering on others. To have to live with an irritable and gloomy person is probably as great an affliction as to be burdened with a painful illness. Accordingly, a man who by inattention to the conditions of a cheerful frame of mind becomes the source of numberless vexations to his family may really produce as much suffering as many a well-recognized criminal. It is

almost amusing to see how men will seek to excuse themselves for their carelessness in these matters on the ground that they are sacrificing themselves to some useful object, some form of public service. It may often be doubted whether even success in their endeavors would result in any benefits at all commensurable with the ills brought on their families. And in any case it may not unreasonably be contended that usefulness, like charity, should begin at home. A great novelist and moralist has recently satirized the common neglect of public interests by the English *paterfamilias* whose largest conception of public good is the welfare of his family. The case is no doubt common enough; but its commonness must not make us overlook the evils of the other extreme, the carrying out of something which is supposed to be of public value at the cost of the comfort and enjoyment of the public benefactor's family and friends. If moral worth is to be estimated by the amount of happiness bestowed on others, it may well be doubted whether some of these self-sacrificing persons of large aims are not of inferior value to many a commonplace good-natured citizen, who is perfectly free from all lofty aspirations, who likes to live well and to surround himself by happy faces, and whose healthy instinct for pleasure leads him unreflectingly to add to the enjoyment of all who have to do with him.

In many cases, then, it is clear that people do not think enough of the simple pleasures of life. It may be added that, in order to realize in one's self and in others the full benefit of a pleasurable existence, it is necessary to pursue pleasure as something intrinsically desirable. It will not do to seek it merely as a means to an end beyond itself. Pleasure must be loved and sought in and for itself, if it is to be the good which it is capable of becoming. A man should be steeped in the atmosphere of happiness if he is to realize the efficient and beneficent existence we have described, and this presupposes what may paradoxically be called a disinterested liking for pleasure. It is by no means easy to persons of a certain temperament to cultivate the spirit of enjoyment in this way. In truth, it may be said to be the result of a difficult art which will only be acquired by those who have reached a high pitch of moral culture. To foster and manifest a cheerful and gladsome mind often involves a considerable amount of self-restraint in repressing and banishing those gloomy reflections to which one may be constitutionally prone. There is further a certain moral sluggishness and inertia in some natures which makes it a considerable effort to rise into the pleasurable strata of the emotional atmosphere. How often, for example, is a fit of mental depression only capable of being dissipated by a vigorous form of bodily exercise to the idea of which the feeling of the moment is strongly opposed! The creation and sustentation of a bright and joyous consciousness is thus often a matter of real difficulty, and deserves to be extolled as a moral triumph over natural inclination.

It may be well to add that this conscious pursuit of a happy tone of mind will demand a good deal of individual self-assertion in the face of the claims of social custom. If a man is to succeed in being a radiant center of happiness, he must, it is plain, be free to seek enjoyment in his own way. We do not mean merely that he will naturally disregard the force of example so far as to avoid the extreme heat of the struggle for existence. It is only too obvious that, if he desires a healthy, cheerful condition of mind, he must take life in a measure easily and abandon all excessive ambitions. What is less obvious is, that he will have to hold aloof from many of the forms of fashionable enjoyment prescribed by society. These prescriptions are often exceedingly foolish, having no relation to individual tastes. For example, the late dinner-party, though supposed to be a source of enjoyment, is really adapted to induce in many persons a permanent feeling of depression and weariness. It would perhaps not be edifying to inquire how much of the chronic discontent and mental discomfort of people arises from a too ready compliance with the demands of fashionable society with respect to amusements.

But the reader may object that we are here taking only one view of our subject. Is it not, he may ask, a dangerous doctrine that pleasure is a good thing, deserving to be cultivated with ardor and assiduity? No doubt the pursuit of personal enjoyment must not be made the sole aim of life. To use Mr. Spencer's language, egoism must be balanced by altruism. Yet, while allowing this, we would contend that a wise and calm regard for a continuously happy existence is a much less inadequate guide to right living than many moralists are apt to think. They forget that the preservation of an habitual flow of pleasurable feeling is not possible where exciting indulgences are sought after as the chief thing in life. It is really a defamation of the idea of pleasure to call a sensual person addicted to wild excesses of enjoyment a man of pleasure. The true man of pleasure is rather he who tries to carry the atmosphere of enjoyment into all the circumstances and occupations of the day. Those who thus seek pleasure rationally, avoiding all fatiguing over-indulgence, and giving the highest value to the quieter and more expansive forms of enjoyment, will not perhaps greatly fail in a due consideration of others' interests. For, as Mr. Spencer has shown in this same volume, a considerable dash of altruism is a necessary condition of a full experience of personal gratification. This is true even in our present imperfect stage of social development. And if, as he thinks, and we would fain hope, things are tending to a complete formation of the social man with an adequate capacity of sympathy, it must happen by and by that the most thoughtful and judicious cultivator of personal happiness will at the same time be most serviceable to others. However this may be, Mr. Spencer has rendered a timely service in exposing the absurdity of an undiscriminating disparagement of the pleasurable disposition,

and in showing how valuable an element in the economy of life, individual and social, is the instinctive impulse toward enjoyment. —*Saturday Review.*

INTEMPERANCE IN STUDY.*

By D. HACK TUKE, F. R. C. P.

HAVING met from time to time with cases of brain-fag, and also actual insanity, arising from excessive mental work, I wish to direct attention to-day to this cause of disordered mind, not because it is so widespread a cause as many others, but because for this very reason it is in danger of being treated with indifference, whereas at the present moment I regard it as a serious evil, although comparatively restricted in its operation in consequence of the great mass of the people falling under opposite influences; still I fear that it is in schools and colleges as well as in the cottage of the laborer and manufacturer, among students as well as among those who delve and spin, that we must seek for the causes of mental disturbance if we wish to understand them thoroughly.

It would occupy too much time to detail the cases to which I refer; I must ask you to take them as "read." For my present purpose it is sufficient to say that they have taken the form of brain-fag, mental excitement, depression of spirits (sometimes suicide), epilepsy, and chorea. I have recently known a case of acute mania distinctly due to this cause, confinement in an asylum becoming necessary. Of suicidal melancholia I could cite some painful instances, and, as regards epilepsy, I could detail the history of some marked cases resulting from overwork; and I may state that, at the National Hospital for Epilepsy in London, pupil teachers have been admitted laboring under this disease, brought on by mental strain. Two medical officers, resident in the institution at different times, spontaneously drew my attention to the fact.

I fully admit that, in many instances of mischief from excess of study, this results from anxious worry as well. The subject "preys on the mind," as people say; but then it was the study of too large a number of subjects or of subjects beyond the power of the student to master within a given time which was to blame for this harass.

Here I wish to anticipate an objection which may be raised to my own observation and experience on this question. How is it—it may be fairly said—how is it that, if over-mental work is often to blame for attacks of insanity, there are not more statistics at hand to prove it? To this I would reply:

* Read in the Psychological Section at the Annual Meeting of the British Medical Association in Cork, August, 1879.

1. The principal statistics in regard to the causes of insanity are derived from asylums for the uneducated classes.

2. An attack of excitement caused by mental strain in the young is often temporary, and is treated privately.

3. When suicide is successful before the patient reaches an asylum, the case is not to be found in lunacy statistics.

4. Cases of epilepsy often remain at home; and the same remark applies, of course, to brain-fag and general nervous exhaustion.

In regard to one of these points I would observe that, when I have been able to examine into the causes of cases of insanity admitted into non-pauper asylums, I have found a considerable number traceable to excessive mental work either as a predisposing or an exciting cause. No doubt this is often associated, as I have just said, with anxiety and other emotional states. It is sufficient, however, for our present purpose if it be admitted that a considerable number of attacks occur in connection with overwork, although complicated with emotional excitement. It must be remembered that the mischief thus done is only one part of the evil wrought by the intemperate pursuit of knowledge. The lungs and other organs also suffer. Dr. Andrew Clark writes to me: "I am a witness to the grave and sometimes irreparable mischief done at schools and in working for competitive examinations. As an illustration," he adds, "of the evil effects of overwork for competitive examinations, I can say that, of the young men passing the Civil-Service Examination for Indian Service, and afterward sent to me by the Civil Service Commissioner for health certificates, ten per cent. during the last three years have had temporary albuminuria."

I have before me tabular statements of the school hours and the subjects taught in some of the principal English public schools, as well as in private seminaries. It is utterly impossible to present them to you in the brief period allotted me; I can therefore only offer a few general remarks upon them, and refer to two or three by way of illustration.

The number of hours actually spent in school does not (as a general rule) appear to be excessive in our large public schools. There are exceptions, but this evil and the multiplicity of subjects taught apply rather to the private schools. Where the chief danger seems to lie in most schools is in the encroachment made on the play-hours. In some day schools the lessons set to learn at home are absurdly long and tedious. I find that in other schools, public and private, a great deal of work is done during the period nominally allotted to recreation only. This is a very important part of the actual school-system, and one which requires great care on the part of masters. I will now take the school hours of the sixth form in one very excellent school for the middle and higher classes. There is an hour's work before breakfast, three hours in the morning, four hours in the afternoon, and two hours in the evening, making a total of ten hours for study. Between breakfast

and supper there are about two hours allowed for recreation. While it must be remembered that, when we speak of boys being engaged in study for ten hours, those who are lazy are not closely and continuously engaged in their work, and that if the master is not strict the strain is not necessarily severe, I can not but think that it would be better for the health of the scholars in this school if the total amount of time engaged in school or study did not exceed eight or at most nine hours. I am quite alive to the danger attending too liberal an amount of time being left at the disposal of schoolboys; they do not find it difficult to get into mischief. Still, under proper supervision, three hours' relaxation between 9 A. M. and 9 P. M. does not seem to me an extravagant allowance for growing lads.

I have referred to the encroachment of book-work on play-hours. Having taken great pains to get at this point in various schools, my conclusion is that, what with back lessons, impositions, and extra subjects, this encroachment becomes in many instances a serious burden. I have been puzzled at first to explain the ill health of some boys when I examined the time-table, and did not succeed in explaining the mystery till I discovered how much of the play-time was really spent by them in work. This is, no doubt, often the fault of the boy, who has not properly learned his lessons, and has to relearn them when he might have been at play. It would be well, however, if the masters would consider whether they do not sometimes, by the amount of work set the boys, render it difficult to those who have only average ability to do all that is expected of them without encroaching on the time of recreation.

In one school I find, as might be expected, that some boys do and some do not complain of the pressure put upon them out of school. I believe this arises in these instances from a difference in facility of learning and not indisposition to work. One pupil, who has left school, and loyally observes, in writing to me, "I feel bound to stand up for a system to which I owe so much," reluctantly admits that the number of lines of poetry and prose which have to be committed to memory is quite unreasonable. The danger of overtasking the brain is here, I believe, by no means an imaginary one. The repetition, which goes on gradually accumulating during the term, of some sixteen or eighteen lines of Greek or Latin verse at each lesson, becomes at last a heavy load for the memory; and my informant adds, "At the end of term I have known over one thousand lines demanded, with only a day's time to look them over in, the usual amount being four hundred to seven hundred lines in the upper forms on the classical side." Another scholar, in a different school, writes: "I have never known more than thirty new lines of Greek or Latin set for one lesson. No time is specified for learning the lines, but they have always to be done between evening school one day and morning school the next, unless the master chooses to set the lesson before." Here we see how

important it is, if we wish to estimate the real amount of brain activity in the twenty-four hours, to inquire into the out-of-school tasks, for while, when looking only at the time-table, we may picture to ourselves a boy comfortably asleep in his bed, he may in reality be engaged in hammering his Greek lines into his brain. The same pupil writes: "The extreme variableness of the work makes it not improbable that some boys (as I did myself at one time) have to work the whole day without intermission (i. e., of course, during whole school-days), and many, especially in winter, work all the evening, from a quarter-past six to ten o'clock, with only an interval for supper."

A teacher of languages in England complains that his son, who is at the grammar-school at ——, has lessons given him to learn which occupy him until ten at night. A gentleman in Devonshire informs me that his boy brings home from school tasks which frequently keep him up till midnight. At a high-school in a large town, I know that some of the pupils have suffered from overwork; two in one family have recently died from "brain-fever," due, it is considered by a medical man, to this cause. Dr. Fayette Taylor, of New York, has drawn a graphic picture of what the Americans are suffering from intemperance in study, and we should do well to take warning from it. "Girls arrive at twelve or fourteen, and, at the threshold of the most important period of existence, utterly unfitted for passing through it. Excitable, with wide-open eyes and ears for every sight and sound which can excite feeling, vapid and intense in mental activity, with thin limbs, narrow chest, and ungainly back, we meet these twelve-year-old products of civilization going to school with an average of thirteen books under their feeble arms—for I have found by actual count that thirteen is the average number of studies which they 'take' nowadays."

I may here record the hours of a school for girls, which appear to me to exceed what is wholesome, and to be well calculated to lessen their mental elasticity and interfere with their healthy development. These girls rise at 6.25; prayers are at seven, and breakfast at a quarter to eight. Their studies commence at a quarter-past eight and last till twelve, with a break of a quarter of an hour; then dinner, during which silence is enjoined and a book read aloud; then an hour's recreation is allowed. Needlework and school-work follow for two hours; half an hour's recreation succeeds, and then come two hours and a half of study and instruction of various kinds. The next meal after the twelve-o'clock dinner is at half-past six, and this is the last. It is succeeded by half an hour's recreation, and this by half an hour's study. Prayers end the day at half-past eight. Here we have nine and a half hours (including religious exercises) of sedentary occupation, and only two hours and a quarter for recreation and one hour and a half for meals. I think we shall be agreed that a little less school

and a little more play would be desirable, and that there need be no cause for surprise to find that many of the scholars suffer from headaches, anæmia, arrested development, and various manifestations of exhausted nerve-force.

Then there are the school *examinations*, and these, I am satisfied, require great care, while most useful means of rendering the knowledge acquired by the pupils definite. A former pupil in the sixth form writes: "With regard to examinations, an hour's examination in each subject was supposed to take place once a month. At the end of the term we had from a week to a fortnight's examination in all subjects prepared during the term. *Making fellows learn up all their repetition at end of term, and keeping them back if they fail to say it, I consider a piece of barbarism.*" I believe that in many schools the examinations at the end of the term embrace so many subjects, and lead to so much cramming of minute details, that from these causes and the spirit of emulation excited the brain is often unduly stimulated, and a state of commotion induced which is highly undesirable. It is true that a long holiday then comes to the scholar's relief, but even an extremely long holiday does not render it safe to undergo extremely severe mental strain. I suspect that with some it is thought to do so, but it is most important that this error should be clearly pointed out. A schoolmaster recently remarked to me that a boy would sometimes answer the first paper in the examination *very well*, the next *not so well*, and by the time he was engaged in the last questions he would be *muddled and stupid*. "He seemed to have got to the end of his brain," as the master aptly expressed it.

I wish now to refer to the present system of *medical* education. How can it be otherwise than injurious when we consider that during recent years the amount of knowledge which it is necessary to master has prodigiously increased in every department, while the length of time in which to acquire it remains the same?

In regard to some examinations, a tremendous burden is laid upon the memory. There is a long period of strain, the climax of which is reached when the period of examination arrives, during which the student's mind has to hold in solution the details of knowledge on many subjects. It is often a solution saturated with minute facts and figures, many of which are of no permanent use, and indeed can not be remembered any longer. The mind is cramped and narrowed by this mischievous cramming, as must necessarily happen when the issue of an examination is made largely to hang upon a retentive memory.

While no one proposes to go back to the old system of medical education, it may well be doubted whether the character of these examinations is calculated to develop the best practitioners or physicians, loading the memory, as they too often do, at the expense of breadth, depth, and originality. The lectures delivered in the medical

schools are, of course, influenced by the examinations, and is it not notorious that these now give so many different hypotheses and enter so much into detail that the student is often perplexed? And (if report may be credited) the lecturer himself sometimes becomes perplexed also.

Too rapid an acquisition of knowledge—the attempt to master too many subjects—is a part of that Jehu speed at which we are now driving, whether in business or science. Knowledge so gained "proves but of bad nourishment in the concoction, as it was heedless in the devouring." So said Milton in his day. What would he have said now? Competition is not confined to trade. Our examination boards have, in truth, not escaped from its influence. It is melancholy to see that the errors we deplore are perpetrated by men whose knowledge of physiological laws ought to have prevented them from pursuing so disastrous a course. Professor Humphrey has protested in terms of strong disapproval against the system of examinations now too generally pursued, and we of all men ought to join our voice with his in the endeavor to stem the current of this excessive and indiscriminate brain-stuffing. "Knowledge grows, but man stands still; that is to say, the intellect and powers of man are no greater now than they were in any of the known past ages; in the days, for instance, of Homer or of Plato, of Confucius, of Buddha, or of Moses; no more powerful to mold the material at hand, whereas the material has vastly increased. . . . Had Hunter been trained upon the present system, had he been weighed down by tightly compressed facts when a student, and subsequently, by out-patient-seeing, on the one hand, and pupil-cramming on the other, it is scarcely to be supposed that even his mind could have burst the iron fetters, and could have regained its elasticity and love of work, or that even he could have found time for those reflections which gave such impulse to the science and practice of surgery." ("Hunterian Oration," February, 1879.) One source of mischief lies in the fact that an examiner constantly forgets that the department in which he examines is only one of many, and hence he requires a degree of perfection which is simply absurd—one which, however, suited to honors, is totally unreasonable in a pass examination; and it must be remembered that the severity of an examination can not be gauged by a reference to the questions which happen to be asked at a particular examination. The student has to prepare himself for all possible questions, ranging over very wide areas of knowledge, and involving an acquaintance with a multitude of speculations put forth by Continental as well as English writers. Hence it is not surprising if, in the anxiety to pass the ordeal, success is too often won at the risk of prolonged mental prostration. Failure, on the other hand, involves, besides this, the dangers arising from disappointment and chagrin.

I should not have thought it at all probable, when I commenced

this paper, that before I concluded it I should have listened to far stronger remarks than any I have indulged in, in an assembly of medical teachers and practitioners in London at a meeting of the Metropolitan branch of this Association, under the presidency of Dr. Andrew Clark. On this occasion, Mr. Huxley said that to expect students to pass an examination in the subjects on which they are now examined, after only four years' study, was little short of "criminal." He characterized the attempt "to cram the student with all these subjects as utterly preposterous. The amount of work expected is simply gigantic." Mr. Hutchinson said: "The best memories stagger under the present load. . . . That after four years' study a student can be expected to bear his subjects in mind is simply an *absurdity*."

But it is time to ask, What is the remedy for these evils?

First of all it is necessary to make them widely known. Educators and examiners must at least have no chance of sinning from ignorance, although, as I have said, some who know most of the laws of physical and mental health are the chief culprits. It must be insisted that they are oftentimes putting too heavy a weight upon the camel's back, and it is for them in the first instance to consider in what way they can best diminish the tension, and, as regards medical education, rearrange the curriculum. What I complain of is that at the present moment the tendency in certain quarters is to render this curriculum, and consequently the examinations, harder and harder, more and more unpractical; so that many can feelingly unite with the Earl of Ellesmere, who said to a friend, shortly before his death, that he was not sorry to go. The world was clearly becoming very disagreeable; everybody was going to examine everybody, and he was sure *he* should be plucked!

In the second place there must either be a change in the character of medical examinations, or the period of time occupied in study must be extended. I believe that the first is absolutely necessary, and that the second is in any case highly desirable. As regards the change in the character of the examinations, it should be in the direction of lessening the demands made upon the memory; and, as regards length of time, I think a year more than is now required would be a great advantage. It would also be an immense gain to the student if, while he is engaged in hospital-work, he should have no examinations hanging over him, except "medicine" or "surgery." This means the subdivision of medical examinations.

Mr. Hutchinson proposes that students should be thoroughly examined during their curriculum (by hospital teachers or traveling examiners) on the various subjects, and bring up certificates of proficiency to the Examining Boards. These would accept the certificates as proofs of competency in details, and would give a good, general, practical examination before granting a diploma. If this course be adopted, and is not overdone, it will certainly be an immense improvement

on the present system, and would prevent students leaving too much of their work undone till the last year.

Thirdly, it seems to me of great importance that the number of subjects examined upon at the same time should, in some instances, be reduced. The original idea of the London University in arranging the subjects for the examination of M. D. was excellent—namely, to spread them over a sufficient number of years and to present them successively in a natural order of gradation. But, now that the mass of knowledge demanded has so vastly increased, this division of labor only partially meets the difficulty of the student, for he has now to be prepared to answer questions in the course of a few days which demand a painful retention of an enormous number of facts in the memory. Some relief would be obtained here by a longer interval being allowed between the days of examination on different subjects.

In the recent discussion on medical education to which I have referred, Mr. Huxley urged that one mode of relieving the present strain would be to make the preliminary subjects (in an elementary form) necessary parts of school education. Thus a boy ought to know a bone or a muscle when he sees it. My fear is that by so doing we should intensify the labors of school-work, unless it is on the distinct understanding that these subjects are not added to, but take the place of, some which are now taught at school; otherwise it is merely cutting off one end of the plank and fastening it on to the other. Mr. Huxley's proposition assumes, of course, that it is well to introduce these studies into schools as a part of the education of all, whether intended for the medical profession or not.

Fourthly, whatever course is adopted, it is, I would hope, unnecessary to say that the crotchets of individual examiners should not tinge the questions, or rather the judgment formed of the answers. If the questions which are now asked are not too severe when taken alone, they are regarded by many competent judges as frequently too severe when taken in combination with the other subjects examined upon, and also that they are sometimes calculated to puzzle the student, from the form in which they are worded. Not long ago an examiner at the London University, speaking to another examiner, boasted of the puzzling questions he had been ingenious enough to ask, whereupon the other replied, to my great satisfaction, "You should try and find out *how much*, not how little, the students know." I should have no fear of the questions being unreasonable when put by a wise, common-sense Professor like this, whereas some learned men expect a student to reach in a few months the level of their own mature knowledge.

I would adopt the language, once more, of Professor Humphrey, and say: "With Democritus 'we should strive not after fullness of knowledge, but fullness of understanding'; that is, that we should strive for good, clear, solid, intelligent, producible, and available knowledge, of the kind that will be useful in after-life; not so much the *re-*

finements of chemistry, anatomy, and physiology, which stupefy and then pass away like chaff before the wind, but the essential fundamental facts and principle, welded together, and so woven into the student's mind that he can hold them firmly and wield them effectually; and that he is conscious of them, not as the goods of other men, or as dogmas which he has because they were imposed upon him, but as his own possession, of which he appreciates the value because he knows how to use them."

In conclusion, I would express the hope that the expression of opinion in the Psychological Section of this Association will strengthen the hands of the Metropolitan branch, which has taken up this question with much earnestness, and, although starting from a different standpoint from my own, has been equally impressed with the evils attending the present system of medical education. *I* am moved by the conviction that its influence upon the mind is injurious; *they* by the fear that it fails to produce the best men, and the belief that it is altogether unreasonable.—*Journal of Mental Science.*

WATER AS FUEL.

By WM. C. CONANT.

THE satyr in the fable was not more scandalized at the man who blew hot and cold with the same breath, to warm his fingers and to cool his porridge, than the old acquaintances of water as the natural cooler and refresher of the world have been to find it artificially asserted as supreme in the opposite office of heating. It may well seem the extreme of paradox that the same element which tempers the excess of both solar and animal heat should also become the great source of supply for their deficiency. And yet why should not the universal absorbent of this power be made to restore it? We have long known that water is but the fuel of the universe as transformed by combustion—a cold residual of a cosmic conflagration that still rages in the central mass of our system, and has hardly subsided as yet in its principal fragments.

Hydrogen—the "water-parent," or distinctive element of water, as its name imports—may be regarded, metaphorically at least, as a metal, which no degree of cold in nature, or where life exists, can reduce to the density of a liquid. It oxidizes so eagerly, and in such infinite abundance, as to be the only combustible comparatively worth mentioning: nowhere to be found, in fact, but in vehement combustion or in its cold result as water, unless where locked in the embrace of its secondary affinity, carbon, in the various oily products of organic life. In the latter condition—the hydrocarbons—hydrogen is protected

from the all-devourer, oxygen, and enters into innumerable uses. As the inflammable ingredient of wood, of bituminous coal, of petroleum and other vegetable and animal oils, we have it sealed up by Providence, as it were, for a temporary and portable fuel, pending the full development of man's proper authority over the elements—temporary, for it has long been a source of anxiety to economists that the resources of forests and coal-fields are so finite and their prospect of exhaustion so definite. It is evident from the coal "measures" that man was never intended to remain dependent on what he could pick up ready made for his needs, in respect of fuel any more than of other things; albeit this provisional supply for his infancy was made ample and accessible above all others. Even the novel service of carbon (which we shall observe more particularly further on) in smelting hydrogen "ore" from the vast mines of lake and ocean—as it does also the oxides of other metals from telluric mines—bids fair to be divided with some more unlimited artificial agency in due time. To the present time carbon, diffused and heated to intense brilliancy in burning hydrogen, has been our only artificial illuminant on a practical scale. And yet it now seems likely enough to be superseded in this office also, at no distant day, by fixed illuminators excited by the combustion of hydrogen or the force of electricity.

The better hydrogen becomes known, therefore, the more interesting and important to us it is found beyond all other elements, oxygen scarce excepted. To all the vital and delightful uses of water, as we have seen, it adds also those of light and heat. For, although scarcely luminous in itself, hydrogen is a principal source of the heat which makes other substances luminous, and is thus a chief condition of illumination. Terrestrial flame is generally hydrogen gas in the act of combustion, colored and made brilliant with white-hot carbon also oxidizing. Carbon may therefore be called a diffused illuminant, and the only one of any importance available at a living temperature, although in the terrific conflagration of the sun all things, even the most stable, are diffused in gaseous incandescence. The more stable substances that maintain their solid form in the comparatively moderate terrestrial heat of burning hydrogen until they become intensely bright are called fixed illuminators. Progressive examples may be cited: in platinum, the most non-fusible of metals, which endures and emits in light the intensity of hydrogen burning in air; and in lime, a still more refractory substance, which glows with dazzling power in the fierce combustion of hydrogen with pure oxygen, commonly known under the name of calcium light.

If Mr. Lockyer should succeed in verifying his startling hypothesis that hydrogen may be in fact the *only* thing in the material universe —not the water-parent only, but the all-parent—our present celebration of this great element would prove neither inopportune nor inordinate!

After all that has been said of it, the nineteenth century furnishes an ever-fresh and amazing retrospect. Within the memory of the living these now common facts—too vast and sublime, however, to be called familiar—were hid, with the great bulk of modern science, indeed, from the sages of the world. Oxygen had but just been discovered, a hundred years ago; hydrogen was unknown; water was supposed to be an elementary substance; fire and flame were mysteries; what the sun might be, and the nature of its light and heat, nobody could guess. After hydrogen had been found elsewhere, it was discovered (in 1781) that water is the result of its combustion with oxygen, and in 1805 that two parts in three of the vast volume of that element pervading and covering the earth are contributed by this ethereal ingredient. Several ways to dissociate the two gases were found, but the common and practical method was and is the contact of steam with red-hot carbon. This, in the absence of free oxygen, results in a transfer of the water oxygen to the carbon fuel in combustion, leaving the water hydrogen free. Red-hot iron answers a similar purpose, forming an oxide of iron (rust) in place of carbonic acid; but the consumption of so valuable an article as iron in the process has hitherto excluded this method from practical use, although there is now some prospect that by deoxidizing the iron-rust it may become available over and over for the elimination of hydrogen at a minimum of cost.

Until a recent date it has been quite generally taken for granted that, since to separate the two gases of water must cost as much heat as they will evolve by reuniting in combustion, there could be no possible profit in forcing the separation for the sake of fuel. Hence, the application of water hydrogen to practical purposes has been regarded as visionary. But there are some considerations on the other side also that seem to have been overlooked. The unavoidable waste in burning solid fuel has been found to range from fifty per cent. as a minimum in the arts up to ninety-five per cent. as a common proportion in stoves, and thus to exceed by several volumes the whole cost of obtaining from water a gaseous fuel which can be used with but insignificant waste. Besides this, the doubted possibility of economizing the carbonic acid has also been realized, and that hitherto worthless incumbrance has been incidentally recarbonized in the process and utilized as carbonic oxide, to an economic success. Direct economies in the process have also been achieved, preventing great waste of heat in various ways, including that of a large amount hitherto lost in cooling off the finished gas. These recent—and American—improvements have suddenly given a practical character to the manufacture of water-gas, and a practical purpose to the elucidation of the subject.

Notwithstanding an unbroken succession of failures in the economic sense for more than half a century, the unlimited and ubiquitous stores of hydrogen "ore" have mightily stimulated inventors to the task of extracting treasure from these mines of fuel. Few objects have en-

gaged the ingenuity of the nineteenth century in so extensive and indefatigable researches, with (prior to 1874) so little result. Scores of patents have been taken out, mostly by French and English inventors, for different methods of obtaining and employing water hydrogen for illuminating purposes; and a number of minor towns and manufactories in Europe have been and are to this day supplied, by as many different methods, with water-gas. Want of space forbids us to review these methods as to their successes or defects. The common inherent obstacle to their progress is the lack of a sufficient margin of economy to overcome the immense vested interests that oppose any departure from the use of bituminous coal. Such a margin can never be attained under the waste inseparable from the use of retorts, heated externally, to which all the European inventors have adhered. One of the best of their efforts is that of Tessié du Motay, adopted and modified by the Municipal Gaslight Company of New York, and lately purchased of the latter for the down-town district held by the old New York Gaslight Company. Its advantages, however, are subjected to an obvious drawback, in addition to others before mentioned, in a necessity for reheating the gas to give it a fixed character.

In short, the test of successful propagation had never been met by any system, in any measure, on either side the Atlantic, until the introduction of the recent American process, which has proved both in theory and practice a consummation and a contrast to the whole previous history of invention in its line.

But illuminating gas, and the struggles of half a century to cheapen it by water hydrogen, have interested us but incidentally as leading up to a later and still more important result—the practical availability of water-gas as *fuel*. In fact, the rapid progress and generally anticipated success of the electric light have given pause to all present enterprise in illuminating gas. New movements are almost suspended, and shares in the oldest and most profitable works are no longer the favorite investment. A probability has suddenly appeared that the uncounted millions of irrecoverable capital invested in gas mains, pipes, holders, etc., may eventually find no other employment but to supply fuel-gas to the households that have hitherto depended on them for light. In view of such a prospect the feeling of the gas interest toward water hydrogen must become seriously modified. The lately dreaded process begins to look like a friend in need—the only hope of rescuing much capital from total loss in the not improbable event of a satisfactory and economical diffusion of the too concentrated electric light.

Our remaining space, then, will be dedicated mainly to fuel-gas, and the process as modified for that product; first, briefly describing the apparatus, and the distinctive processes for producing by it illuminating and non-illuminating or fuel-gas.

Disregarding details, the apparatus consists, substantially, of a

strong brick cupola-furnace with an iron shell, as gas-generator; this connected by a flue with a secondary chamber as superheater, filled with loose fire-brick nearly to the top. The gases generated from an anthracite fire in the furnace are driven by the air-blast through the connecting flue into the secondary or superheating chamber, at the bottom; here they meet a second air-blast, which urges them to a blaze of intense and complete combustion; and in this superheated condition they are forced up through the labyrinthine interstices of the fire-brick with which the interior of the chamber is piled.

So effective are these simple arrangements that, in the few minutes required to kindle the mass of coals in the furnace to a cherry-red, the mass of fire-brick in the superheater becomes white-hot and ready for use. This result is the work of carbonic oxide and other products of imperfect combustion usually passed off in the smoke of our domestic chimneys, and finely illustrates the main point of advantage in gaseous fuel—its more complete utilization. If any of us could see the regular gaseous waste from our kitchen-stoves kindled up in the chimney to a pitch of heat sufficient to melt iron there, it would be a convincing proof of the estimated loss of ninety-five per cent. of our fuel, and would resemble faintly what is done outside the fire-chamber of the Lowe or Strong furnace, and in what answers to the chimneys of our dwellings.

At this point (to return) the air-blast is shut off; the outlet of the chimney is tightly closed; and a cock is turned which lets a jet of steam from a boiler into the bottom of the furnace and up through the mass of glowing coals. Instantly the process of combustion ceases (as between the coal and atmospheric oxygen), and the generation of water-gas begins; in other words, the coal now takes oxygen in combustion from the steam which has been substituted for air, and leaves the water hydrogen free. The hydrogen, lightest and thinnest of gases, which had been pent in the form and consistency of water, is now itself again, expanding to vast volume, like the ethereal *génie* let out of the casket by the Arabian fisherman, and ready to do the bidding of its liberator. At the same time a valve is opened in the upper part of the furnace, which lets fall a steady shower of crude petroleum on the fire. The pungent and fuliginous vapor in which the oil rebounds from the burning coals is a heavy solution, so to speak, of carbon in hydrogen. Into this thick mixture the free water hydrogen, rushing up from the decomposition of steam below, freely enters, diluting it to proper proportions for burning completely and cleanly, without smoke, in the open air. Another ingredient, rolling up from the fiery laboratory, also mingles in the tempest of hot gases, and still further heightens the calorific and consuming powers of the compound. This is carbonic oxide, the great value of which, either in a fuel or illuminating gas, and its spontaneous development in place of incombustible carbonic acid, are among the advantages which have

given to the American method the first decisive success in supplying the public with water-gas.

The oxygen of the steam, as we have seen, on entering the burning coals at the bottom of the furnace, instantly unites in full proportions with the first carbon it encounters, forming carbonic acid. But this carbonic acid, as fast as formed, is driven upward through the fire, and, before it reaches the other gases, its greedy oxygen has gorged itself with a double portion of carbon from the coals, and it is now carbonic oxide—a gas rich with carbon, which is ready to unite in combustion with a further proportion of oxygen wherever it can find it. But it finds no oxygen among the gases to which it is introduced, for the air-blast was shut off when the steam was let on. Consequently, it enters into the compound, and remains as a third combustible.

Meanwhile, the mingled gases are rushing from the furnace, under high pressure, through the flue into the secondary chamber or superheater, and up through the white-hot mass of fire-brick which it contains. Struggling through the hot crevices in attenuated streams, the gases reach a temperature of nearly 2,000°, at which all the elements present are perfectly released and enabled to form such recombinations as their stronger affinities dictate. As the oxygen here finds itself in a hopeless minority, and remains dominated by the superabundant carbon with which it is associated in carbonic oxide, there is no rival to forbid the bans between the king and queen of combustibles—Hydrogen and Carbon.

The charge of coal in the generator makes from five to seven thousand cubic feet of gas: the process of generation taking thirty minutes. The steam is then shut off, and the generation of gas ceases. The lid is raised, the air blast readmitted, and ordinary combustion is resumed. The stoker approaches the fiery pit on a floor level with its mouth and pours in another charge—a barrel of anthracite—fastens down the lid, and for fifteen or twenty minutes the air-blast again urges combustion until the mass in the generator is of a lively red, and the fire-bricks in the superheater are once more white-hot for a second run of gas. At every sixth charge the ashes are raked out, and two barrels of coal, instead of one, are put on.

When the eight sets of apparatus in the Baltimore works are in operation, the actual product per twenty-four hours, with all delays, amounts not unusually to 600,000 cubic feet; and it has been practically demonstrated that 1,000,000 cubic feet could be made by the same apparatus in the same time. Provision is also made for as many more sets of apparatus as may be required by the future extension of the business.

We are now prepared to understand clearly the later and more important process of making pure *fuel*-gas; which commends itself to us as the next great economic stride of the arts, and therefore as the true "objective point" of this article.

The first stage of the process invented by Mr. Strong is so nearly the same with that already described that a repetition is unnecessary, the furnace being fired up until the loose brick contents of the secondary chamber or superheater are at a white-heat, when, as before, gas-making is commenced. But here the current of the process, so to speak, is reversed. Instead of letting the jet of steam in at the bottom of the furnace, we let on steam at the other end of the system, i. e., at the top of the superheater, and pass it directly downward through the mass of white-hot fire-brick. This raises the steam to a perfectly invisible gas, hotter than devouring flame, as it rushes from the superheater, through an extra flue, into the upper part of the furnace. There it meets a shower of anthracite coal-dust instead of petroleum, sifted down into the furnace from above, and literally burns it up with intense combustion—precisely as coal-dust would be devoured in the fierce flame of the blast-furnace seven times heated, except that the oxygen of this combustion is supplied entirely by a steam- instead of an air-blast. In other words, the steam furnishes both heat and oxygen for the instant conversion of the coal-dust to carbonic acid, with the consequent release of its own prodigious volume of hydrogen. Under their own increased pressure, the gases continue without pausing, down though the mass of glowing coals. In making this passage, the carbonic acid takes up a double portion of carbon from the hot coals and becomes carbonic oxide—the powerful heating gas so often seen burning in a lambent violet flame on the surface of anthracite fires when the air is let in on them. As there is no access of atmospheric oxygen to the furnace, there is no opportunity for the combustion either of this gas or of the freed hydrogen, and accordingly both pass out together at the bottom of the furnace, through a pipe which conducts to the gas-holder.

The product of this process, before purification, has been rigorously analyzed by the several methods, by Professor Gideon E. Moore, Ph. D., and proves to be 52·76 per cent. pure hydrogen, 35·88 per cent. carbonic oxide, and 4·11 per cent. marsh-gas, making nearly ninety-three per cent. of the whole volume in these powerful calorific agents, leaving only six to seven per cent. of incombustible waste (carbonic acid and nitrogen). Wurtz also gives substantially the same proportions, in Johnson's "Cyclopædia."

The purity of this fuel is a consideration nearly sufficient of itself to revolutionize the manufacture of iron, and especially of steel, for which, in its perfection, few if any mineral coals are sufficiently free from such troublesome ingredients as sulphur, phosphorus, etc.; but of this further on.

With respect to comparative calorific values, Professor Moore's report shows, by rigorous calculation, that the Strong fuel-gas will produce 2·78 times the practical effect of the amount of coal consumed in its manufacture, supposing the same coal were burned directly by the

most perfect methods of combustion and utilization known in the arts. But in these methods, according to standard authorities, at least five times as much of the fuel is utilized as in the average of stoves. The practical heating value of our domestic fuel may therefore be multiplied fourteen times ($5 \times 2{\cdot}78$) by using it to make water-gas.

But, again, the material actually used at Mount Vernon in making the water-gas analyzed by Professor Moore, instead of being our domestic fuel, worth from four to six dollars per ton in New York, was mostly nothing but waste coal-dust, dug up from an old "fill," where it had been used in grading the street; and when the gas product itself is reapplied to making and superheating the steam—as, of course, it will be—the use of merchantable coal may be entirely dispensed with. Of the refuse dust we have literal mountains accumulated at our coal-mines and depots, as well as constant deposits at every coal-yard, which the proprietors would now be glad to have taken away gratis. Making ample allowance for the expense of appropriating these supplies of coal-dust, and allowing only the lowest price of chestnut coal for the article consumed in our stoves and furnaces, we can multiply the present equivalent for our domestic coal bill at least three times more by the gas process—less the charges for invention and organization, capital and interest, manufacturing management, and distribution. The proprietors propose to have the fuel-gas delivered at fifty cents per one thousand feet, with a good margin of profit, as it can even now be made for ten cents. Compared with illuminating coal-gas by volume, its heating power is found to be about as three to five. Hence, coal-gas at eighty-five cents would be as cheap fuel as water-gas at fifty. But, in point of profit to the maker, the difference at these prices would be greatly in favor of the water-gas; while, in another controlling matter, on the side of the consumer, it is not *malapropos* to say that comparisons are "odorous." The mysterious but not agreeable smell raised by a coal-gas jet of the best air-mixing or total-combustion burner, when impinging on the surface of any cooking utensil (thought by Professor Wurtz to arise perhaps from a synthetic re-formation of gas) is a serious objection to coal-gas cooking, from which water-gas is absolutely free. Its combustion is perfect, without air-mixture, and without smell, "synthetic" or whatever. So far as the hydrogen is concerned, the product of combustion is pure aqueous vapor, in a quantity not likely to overcharge with moisture the atmosphere of the house. The other principal ingredient, thirty-six per cent. of carbonic oxide, becomes, of course, carbonic acid in burning, and must be conducted away.

Using a Goodwin's gas-stove to its full capacity at once as baker, broiler, and boiler—simultaneously baking bread and potatoes, boiling other vegetables and coffee, and broiling steaks and chops, sufficient for a dinner-party of "experts"—Mr. Strong found the time thirty minutes, and the consumption of gas thirty-two and a half feet, or sixty-

five per hour. This (at fifty cents per one thousand feet) was three and a quarter cents per hour for the full running of the cooking apparatus or one and five eighths cent for cooking the entire dinner.

Turning from the domestic to the business arts, we encounter a prodigious revolution on the threshold with the incoming fuel. The gas-engine already referred to, as recently improved and extensively introduced under the German patents of Otto, supplants the steam-engine completely, on the small scale, even at the present high cost of coal-gas, and with certain other drawbacks peculiar to that somewhat tarry article. It is already available up to thirty horse-power, and at fifteen and under it is universally found a much cheaper source of power than steam, and with gas of five times the cost and much less adaptability than the American water-gas. Thousands of these engines are used in England, and in London it is expected that steam-boilers with their smoke and danger will ere long be prohibited where the gas-engine is available. The "silent" gas-engines are also selling rapidly in America on the lines of rural and minor manufactures. What new stride this important substitution may take with gas at fifty cents and free of tarry ingredients, one hardly dares conjecture. But its absolute safety, automatic operation, and slight displacement, open to the gas-engine a vast sphere of common and household uses for which no motor had before been adapted. On the large scale, moreover, we may perhaps live to see such things as gas-locomotives, unburdened with coal or water, rid of their boilers, their annoying smoke, and their destructive sparks, and satisfied with picking up at intervals a plate-iron tender-car full of compressed water-gas.

In hope of closing with a sustained interest, the first actual and one of the greatest possible applications of the new gas-fuel has been left to be last mentioned—that of the manufacture of iron and steel, lately commenced in Sweden, under the American patents and the personal superintendence of a gentleman to whose inexhaustible energy and tact the American water-gas is largely indebted for its difficult yet brilliant progress—Mr. George S. Dwight, of Montclair, New Jersey.

Siemens's gas—a product saved from the combustion of coal in a furnace invented by that distinguished metallurgist—has long been used with admitted advantage in various branches of iron-working. With this well-known and standard form of gaseous fuel, Professor Moore's report, already quoted, minutely compares the American water-gas, showing that the former is many times more expensive and less efficient than the latter. In fact, water-gas made under all the old disadvantages of method is said to have been in use twenty years ago at the Oldbury furnaces near Birmingham, England, and was introduced nearly as long ago in the Yorkshire blast-furnaces. It has also been used with marked preference in France, by workers in the finer metals particularly. Of the American water-gas, Dr. Moore says that its special advantages in metallurgy are, besides its great economy in cost

and consumption, the high and easily regulated temperature it affords beyond all other fuel, and the relatively small volume of products of combustion evolved—being, in short, the most concentrated form of gaseous fuel hitherto available for such purposes. To which he might have added (if he had not been at the moment confining his comparisons to gases) that its freedom from the impurities rife in mineral coals, and that greatly restrict the supply of iron fit for refining, seems alone sufficient to insure its substitution for all other fuel in the manufacture of iron and steel.

That Sweden has been first to move in this direction was natural, from peculiar circumstances. This preëminence of "Swedes iron" has been sustained under a singular disadvantage as to fuel. The country is destitute of coal, and pays a monstrous tax on that grand factor of its leading industry in the expense of importing it from England. On the other hand, it possesses inexhaustible stores of peat, which is well adapted to the manufacture of water-gas by the American process, and will henceforward supply the Swedes with that perfected form of fuel at a cost that will seem to them as nothing.

The operations now going on in Stockholm under the superintendence of Mr. Dwight were initiated by a semi-official body styled the *Jernkontoret* (or Metallurgical Association), which, under the patronage of the Government, pursues whatever investigations and experiments promise advantage to the grand interest of that country. Its voluminous published researches and reports are of standard authority in metallurgy all over the world. Water-gas making was commenced with American apparatus erected in the Atlas Works, Stockholm, in 1879, and the product applied to the treatment of iron-ores and the manufacture of steel. An official certificate of unqualified strength has been published under the signatures of leading Swedish and Russian metallurgists, and new works on a practical scale are now being established. The subject excited extraordinary interest throughout the intelligent classes of the nation. Preparations were also made to conduct the gas into various establishments and mansions for the purposes of warming and cooking. Orders have reached New York for fuel-gas works of the same kind in St. Petersburg, Russia, and preparations were making at the latest advices for similar movements in Austria and Bohemia, as well as to press forward organizations for the supply of American cities with both domestic fuel and manufacturing power in this form. The introduction of a ubiquitous motor (for the Otto silent gas-engine) as handy, cheap, and common as the ordinary gaslight, will mark a new era in industry, and prove an important new factor in political economy.

THE EARLY FREE SCHOOLS OF AMERICA.

By ALICE HYNEMAN RHINE.

WITH the discovery of America, the founding of colonies in the New World relieved the Old of so much surplus population as gave the people of both hemispheres many new chances in life. The advantages of education, meager as was the information given by the schools, inspired men with a desire for larger liberty than the old monarchical governments were either able or willing to give. The men that emigrated to America were of the liberty-loving type. Unfortunately, however, it was love of liberty for *themselves*, not for others. The Puritan fathers, far from being the lofty minded men historians have fondly painted, were bigots, without learning or desire for anything beyond worshiping their own idea of God in their own peculiar fashion. In some respects it was the misfortune of America that these men were the inaugurators of her religious and educational codes. An opportunity so splendid had never been granted to humanity. America started into life with the civilization, the culture, the experience of past ages as her teachers; she was enabled to take up at the last leaf the book of progress which had been commenced cycles before in India, Egypt, Chaldea, Greece, and Rome. The slow emergence from barbarism, the crude and cruel experiences of all other peoples, could have been remitted in her favor; like the fairy princess in the story of the "Forest of Lilacs," her teaching was proceeding while she slept. Had she been able, upon awakening, to make use of this culture—had her governors been men of liberal views and greater foresight—in America the "Utopia" of More might have become a possibility, and the "New Republic" of Plato a successful reality.

Instead of this enlarged freedom, the history of education in America is replete with theocratic superstitions. Theology interfered with the civil laws, and both Church and state hampered with their bonds the free development of education. Colleges were founded, not so much for the advancement of science as to provide learned ministers for ecclesiasticism. In the early colonial times, the Bible, Psalm-book, and Catechism comprised in great measure not only the school-books of the children but the family library. In 1720 we read that but one parish library could be chronicled in the colony of Virginia. This library consisted of three books—"The Singing Psalms," "The Whole Duty of Man," and "The Book of Homilies.

This dearth of reading matter, as might have been expected, resulted in making Biblical stories as familiar to the children of the colonists as the legendary tales of fairies and gnomes had been to the dwellers on the borders of the Rhine and Rhône. The dramatic trage-

dies of Daniel, Samson, Jonah, Jesus, the saints, and Christian martyrs, from being studied in school-hours and talked about at home, became things as real as the daily lives of the colonists.

The struggle for freedom, the importation of secular books, the introduction of printing-press and newspapers, diverted the minds of the people into broader and deeper channels. The men of liberal thought and culture who founded the Republic of the West, such as Jefferson and Madison, agitated the subject of the higher education of the people. It was particularly the desire of Jefferson to have crusades preached against the evils of ignorance, and to have laws established for informing and educating the common people.

"Free schools" had always been, and justly too, a favorite scheme among reformers for elevating the race. American statesmen and philanthropists put this plan in operation at an early period; it met, however, with but ill success at first, owing to the dearth of skillful teachers. One of the early writers says: "The business of instruction in preparatory schools was with few exceptions under the control of inadequate principles; in many instances the commonest business of life was abandoned on the demand for a teacher; and the responsible duties of an intellectual guide undertaken by individuals whose chief recommendation was their dexterity with the awl and hammer."

It was not until over thirty years after the close of the war of 1776 that a regular system of schools at the public expense was established. New England boasted with pride of being the first in education, as she had been in war. Her example was closely followed by the other States. In New York, in 1805, many gentlemen of prominence associated for the purpose of establishing a free school in New York City for the education of the children of persons in indigent circumstances, and who did not belong to, or were not provided for by, any religious society.

These public-spirited gentlemen presented a memorial to the Legislature, setting forth the benefits that would result to society from educating such children, and that it would enable them more effectually to accomplish the objects of their institution if the schools were incorporated. The bill of incorporation was passed April 9, 1805.

This was the nucleus from which the present system of public schools started into existence. Later on, in the year 1808, we find from annual printed reports that two free schools were opened and were in working order.

One of these schools was situated on a large lot of ground in Chatham Street, on which was an arsenal. It was presented by the corporation to the Free School Society of New York, on condition of that organization gratuitously educating the almshouse children. In 1809 the building was ready for occupation; it was a brick edifice one hundred and twenty feet in length and forty feet in width, capable of accommodating in one room five hundred children. In the lower story

was another room which would contain one hundred and fifty scholars, with other apartments for the teachers and the meetings of the trustees.

The other school was built in Henry Street, on ground donated by Colonel Henry Rutgers in 1806; this building was not completed, however, until 1811, and was then known as School No. 2. In appearance it was the same as the one in Chatham Street, but was not quite so large, having accommodations in both floors for about four hundred and fifty pupils. About four hundred children were admitted into the two schools; the annual expense of each was, as near as could be estimated, three dollars per head.

It was the intention of the founders of these schools—among whom the names of De Witt Clinton, Ferdinand de Peyster, John Murray, and Leonard Bleecker stand prominent as officers—to avoid the teachings of any religious society; but there were among the people many who thought that sufficient care was not being bestowed upon religious instruction: to please these malcontents the literary studies of the pupils were suspended one afternoon in every week, and an association of fifty ladies of "distinguished consideration in society" met on this day and examined the children in their respective catechisms. The parents and guardians designated the denomination in the tenets of which they wished their children educated.

Every authority acquainted with these schools expressed satisfaction at the literary improvement of the children. The system employed was that of Mr. Joseph Lancaster, of London, and consisted of class-teaching in reading, writing, and arithmetic. The employment of the scholars, as made up from the printed reports, may be curious reading to many in this era of multitudinous studies.

Children were first taught to form letters in sand; then advanced to monosyllabic reading on boards; from reading on boards to Murray's first book; from Murray's first book to writing on slates; from writing on slates to writing on paper—to reading in the Bible—to addition and subtraction—to multiplication and division—to the compounds of the first rules—to reduction—to the rule of three.

To read, write, and know arithmetic in its first branches correctly, was the extent of the educational advantages which the founders of the free-school system deemed necessary for the accomplishment of their purposes. When proficient in these studies the scholars were apprenticed to some useful trade or given a profession, if the inclination and genius of the graduate seemed sufficient to warrant the inincreased outlay.

This system was better than any that had preceded it. Under its influence the blind obedience that had marked the lower orders of Egypt, the Asiatic and Roman proletariats, and the villeins of the feudal period, passed away. Education, which in the past had been solely aristocratic and theological in its character, became democratic

and secular; it popularized itself in the United States so directly with the people that the various State governments, recognizing that the beneficiaries—who at first were of the class that, *un*educated, would have become a charge to the nation—grew self-helpful, were imbued with the desire to extend educational advantages. Under the sway of popular enthusiasm large sums of money were appropriated; schoolhouses were erected at public expense in all large cities, and in almost every village.

The primary thought of the founders of the new schools was lost: this consisted merely of giving a groundwork of education for pupils to build upon. Grammar and normal schools, as well as universities, arose throughout the land. College text-books were multiplied seemingly without end, and from them everything within the ken of human understanding was attempted to be taught. Instead of the original plan of three or four years being the average length of school-life for *non*-professionals, children were entered at five years of age and left as young men and women graduates.

This system of book-cramming, which was not only without science, but was founded upon neither experience nor observation, was followed by the most unsatisfactory results. The exclusively scholastic knowledge which was imparted unfitted the common people for the exigencies of actual working-life. This guidance of theocratic, feudalistic, and merely scholastic teaching did not result in any adequate social, moral, and intellectual improvement. Is it not time, then, that *Science* and *Art* shall assume control of the free schools of America, and convert them into halls of industrial and practical education?

PREHISTORIC RUINS IN SOUTHERN COLORADO.

By HENRY GANNETT.

FROM the southern and western slopes of the San Juan Mountains, in southwestern Colorado, stretches far to the south and west a strange country. It is a country of plateaus and cañons—of plateaus whose surfaces are flat and unbroken for miles on miles; as far as one can see, the country presents a monotonous level, but is cut here and there by deep, almost impassable, cañons. As we recede from the mountains, these plateaus, which are there covered with piñon pine and sage, become more sterile, and finally vegetation ceases, except in isolated spots, and the surface is bare rock or drifting sand—a very Sahara.

The Rio San Juan heads in the southern slopes of the San Juan Mountains, and, flowing at first south, at a distance of about fifty miles turns west and keeps this course generally to its mouth. It flows

through the middle of this desert country, fertilizing a narrow belt along its course.

In the region drained by this river there is little water. Of the branches which enter it from the north, there is but one stream west of the La Plata which succeeds in reaching the main river. This is the Rio Mancos. All the others, and they are numerous, start from the mountains as large, clear, beautiful streams. They reach the plateau; the water becomes discolored, alkaline, and in a few miles disappears. The dry atmosphere and the parched earth have absorbed it, and a dry cañon alone remains to mock the thirsty traveler. Reaching the edge of one of these cañons, five hundred or perhaps a thousand feet deep, with precipitous sides, one experiences a feeling akin to superstitious fear when, after descending to the bottom, and fully expecting to hear the rushing of a torrent of crystal water, he finds only a stream-bed of hot, glistening sand. The feeling is the same which one has on seeing any other monstrosity. Why this great cañon carved out of solid rock? Where is the agent which has produced such stupendous effects?

Doubtless in the early spring, when the snows in the high mountains and on their lower slopes yield to the power of the sun, these stream-beds are for a short time—a week or two, perhaps—each filled with a rushing torrent; but, like the people who once dwelt near them, the perennial streams, which in time past cut these gorges, have disappeared. Throughout this vast region, with the exception of the streams mentioned, the only water to be had is in springs and in water-holes, where rain-water, protected from the ardent rays of the sun, remains for a time. The sources of supply are precarious, and, without a knowledge of their location, one might travel for days without finding water.

Scattered over the region are the remains of a long-forgotten people—a people which, judging from the few relics left for our study, possessed a far higher degree of civilization than the wild tribes now roaming the country, higher than the Moquis and Pueblos of the present day, yet resembling them in many respects. We find the remains of their homes, their houses of stone, in various places and of various kinds: some, the homes of a happy, contented people, in full security, leading a pastoral life; others, mere *houses* built for shelter and defense in stormy times, as protection from the invader, for concealment, and for open defense. The general outline of their history is written in characters of stone all over the country.

The northern limit of their settlements seems to have been near north latitude 38°. Farther north than this no evidences of their occupation have been discovered, although exploring parties have examined the country thence to the Grand River. Toward the south and west their dwellings have been found in Utah, throughout Arizona, and in New Mexico as far east as the Rio Grande. But here, on the

Rio San Juan and its tributaries, seems to have been a center of population. In this country, over a large area, the villages are quite near together, showing that it was comparatively densely peopled. Their remains consist of buildings in various stages of decay and dilapidation—cemeteries, pottery, most of it in a fine state of division, arrow-heads, a little wicker-work, stone tools of various sorts, partially carbonized grain, corn-cobs, etc., and a few specimens of human remains.

The ruined buildings are, as was stated briefly above, of two general classes, representing two different periods in this ancient history, that of peaceful occupation, and that of invasion by a foreign power and of final expulsion of this people from their homes. All of these structures are of stone, dressed with more or less care, or chosen with reference to size and shape. There is little or no rough rubble-work. In all, the stones are set in adobe mortar, which has great cohesive power, as is shown in several examples.

The first class of structures is found on the fertile bottom-lands, close to water, and they are not arranged with the least regard to defense or security. They were the homes of an agricultural people, and were doubtless surrounded by fields of waving maize and orchards of peach-trees, while herds of goats pastured on the lower slopes of the *mesa*. The men labored in the fields, and took care of the herds; the women assumed the household duties, wove blankets, and molded pottery. But these happy days came to an end: the invader descended from the north and sought to drive them from their country. Long and deadly was the fray. They were driven from the fertile bottom-lands, and were forced to build houses, like the swallows, in cracks and crannies of the cliffs, wellnigh inaccessible from above or below; or they built strong fortifications on the mesas. But all was of no avail. One by one their warriors fell; step by step they were driven southward, until at last, totally discouraged and disheartened, and with ranks terribly thinned, they abandoned the homes of their fathers, and wandered southward, some to build on almost inaccessible heights—the Moquis towns of the present day—some to wander to the site of Zuni, others to the Rio Grande, where their descendants are found to-day: but, as is so often the case with a people forcibly transplanted from their native soil, they have deteriorated from their former state of civilization.

The buildings most frequently met with are rectangular or circular. The commonest form for dwelling-houses is the rectangle. In all cases where possible the dwellings are semi-communistic—that is, each of the houses is very large, intended to contain a number of families, but is divided into many rooms. In some cases, these dwellings, especially in agricultural towns, are from one to two hundred feet in length. At Aztec Spring, a few miles north of the San Juan, is a very large town, built in one mass, and covering 480,000 square feet. In the midst of this, one building, standing by itself, seems to be the principal house of the town, judging by its dimensions, thick-

ness of its walls, and the care displayed in dressing and laying the stone; also by the presence of a circular room, which, as will be seen hereafter, is their temple and council-house. On the La Plata there is a large agricultural settlement, very much dilapidated, which consists mainly of houses of this kind. The largest of these is one hundred by one hundred and fifty feet. These dwelling-houses seem to have been very similar to those in the *pueblos* of the present day. A high wall was built, inclosing a rectangular space. The house was built all around the interior of this wall, which thus became the back wall of the house. In the interior was a rectangular court, on which the house opened. There were no openings for egress or ingress through the wall; the only way to obtain admission being to climb over the wall, by a ladder, and descend in the same manner to the court. The house was divided into many rooms, and, except in a few cases, they did not connect with one another directly.

None of the ruins of these houses thus far examined are in such a condition as to enable one to determine whether they had more than one story. In the pueblos of the present day they are found of three and even four stories in height.

In the towns built in time of war, for defensive purposes, these dwellings are usually much smaller than in the former case, and could have accommodated comparatively few persons: but this is due to the circumstances of building-site solely; for everything in their history shows them to have been a gregarious people. These towns were evidently built later, and in many cases are so situated as to be much better sheltered from the elements, and naturally are found in a much better state of preservation than the former.

In every village, whose site would admit of it, these people have built one or more cylindrical towers, which seem to have been used as council-houses or temples, or both. The walls are generally double, a tower within a tower, and, in one or two cases observed, there is a third tower. The space between them, several feet in width, is divided by radial partitions into rooms. Within the inner tower, the ground is excavated, forming an hemispherical depression. Here it has been supposed that the eternal fire was kept; and it has been suggested that the circular section of the building was intended to symbolize the sun, the object of their worship. These buildings are, in all cases, the most thoroughly constructed; their walls are thicker and of larger and better-dressed stones than in any other buildings. Structures quite similar to these are found in the pueblos of the present day, and are used for the purposes above mentioned. They are always found in agricultural towns, and in fortified towns on the summits of mesas, but in most collections of the cliff-houses and in the cave-dwellings they are of necessity absent.

Well-preserved specimens of these structures have been found on the edge of the mesa above the San Juan, a few miles from the mouth

of the Mancos. Here there are two towers on the very edge of the mesa, so close that the outer walls are not complete, but are open toward the cliff. In the smaller of these towers, the outer wall is twenty-two feet in diameter, the inner twelve feet. In the larger tower, the diameters of the walls are respectively one hundred and forty and one hundred and twenty-three feet. Both are much broken down, so that the original height can not be estimated. In the face of the cliff, directly beneath these towers, are several cave-dwellings connected with the top of the cliff by steps cut in its face.

In the cañon of the Mancos, on the river-bottom, are the ruins of a large tower, the diameters of whose walls are respectively forty-three and twenty-five feet.

On a low bench near the McElms, a dry cañon which heads in the plateau, and enters the San Juan below the mouth of the Mancos, is a large settlement. On one side of the town is a large tower, remarkable as having *triple* walls, whose diameters are respectively forty-five, thirty-five, and fifteen feet. The space between the outer and middle walls is divided by partition-walls, while that between the middle and inner walls is not. In this and all other such structures there are no openings through the walls into the interior apartment. Access to it was had probably through a subterranean passage, as has been observed in at least one case.

Connected with the agricultural and mesa towns are, in many cases, watch-towers usually of circular form, perched on fragments of rocks in commanding positions, whence the approach of enemies can be detected. These are small and with single walls. In the neighborhood of some agricultural settlements are holes dug in the earth, and the earth thrown up in heaps in front, as in rifle-pits. They probably were made for a similar use.

The rocks of which the cañon cliffs are composed are of sandstone and shale. The former is hard and is acted on by the elements slowly, while the latter is easily disintegrated. Hence it is common to find that strata pathways up the cliff have disintegrated faster than those above and below, leaving horizontal crevices of greater or less height and depth. These crevices have been utilized by these people, when hard pressed by their enemies, as strongholds. They built walls across the whole fronts, leaving only little holes for egress and ingress, light and air. Thus walled in, their position was absolutely impregnable from above or below. It is astonishing in what a limited space these beings contrived to exist; some of these cave-dwellings are scarcely large enough for a man to crawl into.

More pretentious than these are the cliff-houses, which are built in similar situations, differing only in the height of the crevices. Many excellent examples of these have been found. They are generally well preserved, as their situations protect them in great measure from the elements. There are several in the cañon of the Rio Mancos. In one

place there is quite a large village, consisting of a series of rooms opening toward the back of the crevice, and with a smooth wall in front, broken only by a few small openings for air and light. Near the middle is the council-chamber, a circular room, as elsewhere, entered only by a very long, low, covered way, or tunnel, built of masonry. This is one of the very few cases where, in similar locations, there was more space than was absolutely essential for mere existence, and the extra space was forthwith devoted to this building, which shows that to it they attached great importance.

Above this village is a crevice similar to the one in which it is built, and this has been utilized as kitchen and storehouse, as is shown by beans and corn which have been found there in a good state of preservation. In the main village whole earthen pots have been found. It is a rare occurrence to find whole vessels, though fragments of them are as plentiful on the mesa as leaves in Vallambrosa's shades.

In another place in this cañon there is a single house high up on the cliffs, which rise still higher above it. It is of two stories. The remarkable feature about it is that the outside is covered with plaster, and painted to resemble the adjacent rock, in red and yellow grays, in the hope of avoiding detection. The insides of the front rooms in each story also are plastered and colored a deep maroon red, with a dingy-white band. Adjacent to it is a cistern to catch and hold the water which trickles down the rocks.

The Casa del Eco is one of the largest of these cliff villages. It is in the cañon of the San Juan, about twelve miles below the mouth of the Montezuma, a dry cañon which heads in the Sierra Abajo. The cañon-cliffs at this place are about two hundred feet high. A vertical and horizontal section of the cliff both present the form of a semicircle; in other words, there is here a cave, in the form of a hemisphere. Along an horizontal curve which passes through its deepest part is a stratum of harder rock, ten feet wide at its widest part, making a projecting shelf, on which is perched the single row of houses of which the town consists. Here the people were entirely protected from attack from above, as the overhanging wall of the cliff projects at least one hundred feet. Below, the slope is extremely steep, making approach in that direction slow and tedious; and, finally, the shelf on which the town stands projects so far that it is wellnigh impossible to get on it without outside aid. The main building of the town, the council-house, is, in this case, rectangular, forty feet by ten, and twelve feet high. It is built in two stories, and each is divided into three rooms. The floor-beams of the second story are of the cedar so common in the country at present, prepared merely by stripping off the bark. Whether these houses had roofs, it is impossible to say. In so protected a situation as this they would be of little use.

In the mortar of these houses there has been detected the imprint

of the fingers of the builders, showing even the fine lines of the texture of the skin, and in one or more places the impress of a complete hand. Their hands appear to have been smaller than the average. Indeed, everything tends to show that this was a race of small stature.

To gain access to these elevated abodes, the people made use of ladders, and of niches which they cut in the rocks.

The amount of labor involved in the construction of these towns was, for a people so absolutely dependent on their own unaided labor, enormous. In some of the cliff-houses, the stones had to be carried for hundreds of feet, up precipitous walls, where the only footing was by holes which they had cut in the rock. All the stone used in the enormous buildings at Aztec Spring was brought from the foot of a cliff fully a mile away, and this without the aid of beasts of burden.

Fragments of pottery are found everywhere. Indeed, it is slight exaggeration to say that the plateaus are paved with them. One may ride for miles with the constant accompaniment of the ring of the horse's hoof against the relics of the ancients. The amount of pottery which this people used was enormous. It would seem that careless servants are not among the innovations of the nineteenth century. Few whole vessels have been found; few, even, of large fragments. These vessels are variously ornamented. The surfaces of some are corrugated, apparently with the thumb-nail; on some, raised figures are seen; others, and these are by far the most abundant, are glazed, and covered with all conceivable figures, rudely painted.

The pottery resembles very much that made by the Moquis and other similar people to-day, but is in many respects superior to it. Arrow-heads seem to have been another staple article of manufacture, judging from the abundance of the specimens. They are made of varieties of quartz; and beautiful specimens, made of smoky quartz, chalcedony, moss agate, and opal, have been found.

The cemeteries which have been examined present a family resemblance. The graves, or family lots they may be, are surrounded by flat stones, set on edge in the earth. The little lots thus marked out are rectangular in shape, with sides six to ten feet in length. Several of these were opened, but nothing was found except a little charcoal.

With regard to the age of these ruins, and the date of the occupation of this country by these people, little has yet been learned. The erosion of cliffs in the neighborhood of the cliff-houses gives no satisfactory data on which to found an estimate. The cemeteries and some of the ruins are overgrown by large pines and cedars, some of them a foot or more in diameter. The Moquis and Pueblos have no traditions concerning these people, who were undoubtedly their ancestors. But neither of these facts gives more than the very general idea that the date of their occupation of the country was several centuries ago.

The ruins are, in many cases, found several miles from the nearest water—a fact which shows conclusively that at the time when these

dwellings were inhabited the country was better watered than now. It has been suggested that these houses were inhabited only for a part of the year, when the streams were high from the spring freshets; but, as the structures are of stone, built with great labor, and in a permanent manner, and as the season when there is water in the streams is at most of but a few weeks' duration, the theory seems scarcely tenable. Moreover, within the observation of white men, the amount of water has decreased. Springs, which a very few years ago were important watering-places for travelers, have decreased in size, and in a few cases have dried up. Still, at that time the climate, though less arid, was in a measure such as it is now, since we find the timber used for beams, etc., in the houses, is the same species of cedar now so abundant on the plateaus—a species peculiar to a dry climate.

The study of the ancient inhabitants of America is one of surpassing interest, and the deep mystery in which the past is wrapped only adds to the zest with which we strive to draw the veil away. But thus far little has been discovered. We know that at some time, far back in the dim past, a great people lived in the Mississippi Valley; that they built there enormous structures, mere traces of which remain, scarcely enough to mock at the seeker after their history. Whence they came, and whither they went, we know not. In the Southwestern Territories we find these structures of a semi-civilized people—whether the same as the mound-builders, no one can tell. No one knows their earlier history; their later history has been sketched in its general features.

THE CONVENT OF THE CAPUCHINS.

By ARTHUR SEARLE.

TRAVELERS to Rome, endowed with a reasonable measure of that taste for the repulsive which is natural to our paradoxical race, have long been accustomed to include in their round of sights a Capuchin convent, noted only for the singular manner in which the bones of its deceased inmates have been made to serve as emblems of mortality to the devout. The published accounts of the spectacle here presented are too generally familiar for quotation. A letter before me, dated in November, 1821, will furnish a description which will at least have the merit of not having already appeared in print.

"I went to the cemetery of the Capucins" (the writer adopts the French spelling of the name), "where we found, in the cellar of the convent, forty graves in the loose earth, always occupied by Capucins in their usual dress, without coffins. When a new man dies, they take up him who has been longest in the earth, coat and all, and place him

on his feet in a niche left in the walls of bones, several feet thick, which ornament the rooms. The niches being also always full, they are obliged to make room here, too, for the new-comer by breaking up and scraping the skeleton which has stood there longest, and adding his bones to the different arches and festoons which are gracefully distributed on all sides. The convent is not very full just now, so that the poor fellows rest on the average seven or eight years in their graves; formerly they were often dug up in two or three."

The earth affording this limited privilege is said to have been originally brought from Jerusalem, so that quarters in it were regarded as peculiarly desirable by the originators of the custom just described; but no doubt an equally important reason for establishing the practice was the desire to edify the living monks by the exhibition of the remains of their predecessors. Heretic sight-seers had not then begun to invade the city. If, however, the possibility of their visits had been foreseen, it might well have been supposed that the silent warnings of the dead might be more effective in their conversion than the arguments of living preachers.

It will hardly be thought that any mere secular sermon may also be preached upon the text furnished by this assemblage of bones. But we have here one solution of the problem, so much discussed in our times, of discovering the proper method for the disposal of dead bodies. We need not allow the various offensive circumstances connected with these Capuchin interments to conceal the main principle upon which they are conducted. The corpses are left to rest some years, without coffins, in dry, sheltered earth, before any step is taken toward their final disposition. If we consider these facts alone, we shall have no difficulty in perceiving that the chief objections to our common funeral usages, and to those substitutes for them which are most frequently suggested, have been met in advance by the Capuchins. The cellar, the standing skeletons, and the festoons of bones are not essential features of the method of interment which they have adopted.

What, in fact, are the causes which have brought coffins for the dead, with all their disagreeable and dangerous consequences, into such general use? Undoubtedly, our natural wishes that the bodies of our friends should be protected, and not left exposed to accident or violence of any kind. Interments without coffins in open cemeteries will hardly be acceptable to civilized people, however much from a sanitary point of view they may be preferable to the customary method. It is needless to engage in a discussion of the repulsive incidents which must or may attend either the use or the abandonment of coffins. We have had them unpleasantly set forth time and again, and may assume at once that all of them are, if possible, to be avoided. The ground ought not to be poisoned either more or less; and we have not room for so wide a separation of one corpse from another as to make our interments quite harmless.

It may here, of course, be objected that the earth is really spacious enough for all our wants, and that crowded cemeteries are the result of heedlessness, not of necessity. But in this remark there is no more truth than in the commonplace answer to Malthusian arguments, that there are plenty of thinly settled districts still to be occupied. Space there is, no doubt, both for the living and for the dead, if they could be conveniently carried to it; but there is often too little space where people find themselves obliged to live and die. Crowds are a necessity of progress, it seems; at all events, the art of getting on well in solitude has not yet been discovered, and we are required by nature to find ways of helping our neighbors where they are, rather than of sending them away. At least, let us find ways to avoid injuring them.

Provision must be made in the neighborhood of large towns for numerous interments. The land available for the purpose is limited by the wants of the living, who can not afford to leave large tracts unoccupied. To make cemeteries serve the purpose of parks and pleasure-grounds would be certainly indecorous and probably unwholesome. On the whole, it is scarcely possible that, under existing circumstances, our burying-grounds should not be overcrowded.

For the inhabitants of maritime districts it has been suggested that the sea, at a sufficient distance from shore, might serve a good purpose as a cemetery. But the practical objections to this plan, resulting from occasional periods of stormy weather, and from the impossibility of recovering corpses wanted for identification or for medical examination, are sufficient to condemn it. It would, moreover, be disagreeable in most cases to the feelings of surviving relatives and friends, and acceptable only when, as at present in many cases of death at sea, it is the only practicable method.

Most of the objections just enumerated apply with equal or still greater force to the more frequently discussed method of cremation. It is not desirable, either from a legal and medical or from a sentimental point of view, that a body should be destroyed soon after it has ceased to live. To effect this destruction in a thorough and decorous manner by burning is expensive, if attempted without complicated apparatus, the original cost of which must, in any case, be considerable. We may neglect more remote and perhaps fanciful objections, such as, for example, that the world's natural stock of ammonia might be seriously reduced in the course of centuries, if the process of decay were extensively replaced by that of complete combustion.

After reviewing the various substitutes for burial which have been tried or suggested, it happens with most minds that none of them seem on the whole to be improvements. It remains, then, to find a form of burial which will accomplish its purpose effectively and without offense or danger to the living. This form must, accordingly, be such that the earth employed for the purpose of burial shall be free from moisture or any other hindrance to rapid and inoffensive decom-

position, and entirely separated from the ground through which the rainfall which feeds our springs and lakes is to pass. The corpses must be buried without coffins, and still be protected from disturbance or defacement by animals of any kind. The only means of securing these ends is apparently to have all interments made in dry earth contained in secure and properly ventilated buildings.

It is, of course, impossible that under such a system the same place should not, as a general rule, be used repeatedly for successive interments. This is mainly a question of expense. In most cases, after the course of nature had thoroughly removed all that could decay, there could be no objection to the disinterment of the skeleton. Cremation would now be a comparatively cheap method of preserving the remains from any treatment which might be held to be indecorous, and the passage of time would ordinarily have removed all occasion for the natural feeling which makes us shrink from doing any violence to a recent corpse. The earth used for the interments might, of course, be thoroughly heated at long intervals, to destroy any accumulation in it of organic products; or, indeed, unless the expense were considered a foolish one, charcoal might take the place of earth, and be ultimately burned with the bones contained in it.

A principal advantage of this method of interment is that it may be employed at any time by individuals without waiting for general adoption. A water-tight tomb may be constructed without very great expense in any ordinary cemetery, and, if the ground around it is suitably drained, may be used for a long while without fear that it is a menace to the health of the community, as all ordinary graves and tombs undoubtedly are. The most economical way of providing sheltered graves, however, would probably be to erect for the purpose buildings of considerable size, within which space might be hired in perpetuity or for limited terms of years. It is possible that such buildings might stand at no great distance from others without harm, under suitable regulations for the interments to be made in them. If constant attendance were provided for, the fear of premature interment which distresses some people might be to a great extent removed; and in any case the protection of the corpses might thus be efficiently secured. Memorial tablets, which might finally be removed to any place selected for the reception of the harmless ashes, would be a welcome substitute for the clumsy monuments which disfigure our present cemeteries; and, without any of the offensive circumstances attending the interments of the Capuchin convent which have served for the text of this article, we might apparently secure their substantial advantages of economy of space and moderate rapidity in effecting the true purposes of burial.

ATHLETICS IN SCHOOLS.

THE Honorable Edward Littleton, an authority in English higher education, has written a notable article in the "Nineteenth Century" on "Athletics in Public Schools." He canvasses the system with some thoroughness, and arrives at independent conclusions regarding it, which will be of special interest on this side of the Atlantic, now that such vigorous efforts are making to adopt the same policy in our higher schools. We accordingly give a summary of the chief points of his essay.

He begins by remarking that intelligent Frenchmen are in the habit of highly commending the English public schools. But, when asked the reason, they always refer to the admirable "*culte* of athletics" which English students enjoy. This surprises the Englishmen—first, because the French have no such thing in their schools, and the Frenchman is therefore speaking about that of which he knows nothing; and, second, because the English themselves are beginning to have profound misgivings in regard to the influence of this marked feature of their educational system.

Mr. Littleton first states the undoubted advantages to be derived from athletics. They are to be encouraged on the grounds of health, as there is unquestionably an hygienic value in games for boys. Again, pastimes afford a relief from the repulsive restraints and monotonous labors of the schoolroom, and are thus promotive of enjoyment. There is, moreover, a benefit in the discipline they afford. The boy who is a member of an athletic club or combination is "forced to put the welfare of the common cause before selfish interests, to obey implicitly the word of command, and act in concert with the heterogeneous elements of the company he belongs to." Those, besides, who secure the posts of command, "feel the gravity of responsible office, and the difficulty of making prompt decisions and securing a willing obedience."

But the difficulty at once arises how to restrain athletics, so as to get only their undoubted advantages. They have a tendency to excess which becomes subversive of the fundamental objects of the school; and for this excess Mr. Littleton shows that the outside public is very largely responsible. How rapidly this influence has been developed and brought to bear upon the schools during the present generation is well illustrated by the following passage: "Any one who played in the Oxford and Cambridge or Eton and Harrow cricket-matches thirty years ago can testify that there were scarcely enough spectators to form a continuous line round Lord's cricket-ground. In the latter match it was not found necessary to use ropes till 1864, while now, such is the importance of the annual pageant, that it affects the duration of the London season. At about the same date a few keen parti-

sans gathered together to see the universities contend in rowing. Little was said about it, scarcely anything written. Nowadays the crowd assembled to see the practice of the crews equals the number of those who used to watch the actual race; moreover, the minutest facts connected with the play of each oarsman's muscles are anxiously picked up on the spot, form a paragraph in the daily papers, and are telegraphed to the antipodes. Deducting from all this the influence of fashion and the mere gregarious tendencies of society, it is quite clear that there has been a dead set of public feeling toward increasing the importance of all athletics. In short, the tide has borne all before it, and scarcely a warning voice has been heard hinting at the possibility of going too far; and, consequently, very many boys soon after they enter the schools (some of them before) are impressed with the notion that athletics are to be pursued as the one important thing—in conjunction with reading, perhaps, *si non, quocunque modo*—but pursued with every nerve they must be."

Of the elements of danger developed in the system under this powerful pressure, the writer remarks: "At first sight, any one would say that its chief danger in the present day lies in the superfluity of time devoted to various out-door pursuits at school. This is wrong. I do not deny, of course, that too much time may be, and not unfrequently is, absorbed daily by games; but that is not the chief danger: authorities could easily suppress an extra hour or two if they saw fit. But it is not generally realized that the effects of games last far beyond the close of play-hours. Leaving out of sight all physical considerations, over-fatigue, etc., which are nevertheless very important, let us look merely at the effects on the mind. Suppose the case of a lad in a school where athletics are much thought of, who is perhaps just emerging from obscurity because it is found that he can row or bowl well. He finds himself with an unlimited prospect of fame before him; if he makes a great struggle, some important step in his 'young ambition's ladder' will be reached; he will be elevated into a social atmosphere now tenanted by the high ones of the earth, who look down on him scornfully, but, in the event of his success, would soon be walking arm in arm with him. A fascination, unimaginable by the outside world, urges him onward, and, with a sense of his increasing importance, comes an increasing appreciation of the method by which he has risen; so that, even with his books before him, his mind is wandering among the scenes of his ephemeral triumphs and reverses while he ruminates on his last big innings or the prospects of distinction in a coming foot-ball match. Prizes, places in the school, are but little things, and are treated as of little worth. This statement of the case is not a whit exaggerated as far as the majority of athletes are concerned. It needs a very exceptional boy indeed, after having been engaged in an absorbing pursuit, to unshackle straightway his energies and thoughts simply at the call of duty, probably uninviting, irksome

duty. But the athletes are not the only ones affected. Wherever athletics are very popular, around the coterie of successful gamesters is formed a large hoard of hangers-on, boys who admire muscle without possessing it, and who, formed by nature for a very different line, adopt the habits and opinions of the superior class, till, perhaps without participating, their interest, too, is absorbed by the prevailing rage, and the tone of the whole community is affected. Under these conditions, work, honest, spontaneous effort in other lines but amusement, is impossible."

The potent fascination of athletic games for boys is undeniable, and that they must greatly interfere with legitimate school-work it would be also folly to question. But, admitting that they hinder intellectual progress, it is common to affirm that there is a great compensation for this loss in the moral benefits of athletic training. It is said that there is a much more important thing in schools than book-learning, and that is to improve the moral tone of students. But Mr. Littleton insists that it is far from being established that athletic games intensely pursued are any check upon vicious tendencies. He maintains that, where athleticism is so engrossing as to stunt the higher life of a school, it is not promotive of virtue, and that, "among schoolboys, the mere students are as a body more virtuous than the mere athletes." He does not affirm that among university students the athletes are more immoral than those who neglect physical recreations. The main question, however, here, is one of mental indolence and vacancy, and Mr. Littleton says: "An energetic athlete, without an idea of any other pursuit whatever, is better off and less likely to turn out vicious than a wholly idle university man or schoolboy; and the appreciation of this fact seems to have led people into investing athletics with a power of stemming vice; the truth being that they are in a limited degree obstructive of it—but only in a limited degree; and it is quite erroneous to suppose that in any educational institution a predominance of athleticism necessarily brings with it a high standard of morals." It is the absolute supremacy of recreation over study and the resulting lack of steady and wholesome mental occupation that lead to immoral consequences. A positive and serious evil of athleticism is, that it tends to become a power in the schools, rivaling the constituted authorities, and that is capable of becoming an enemy to discipline. The spirit of athleticism becomes organized, and the class devoted to it, representing the most powerful feeling in the institution, grows formidable, so that the teachers must ally themselves with it, or lose their control over the pupils. "As is sometimes remarked, no public functionary, no clergyman, no military commander, certainly no prime minister, assumes his powers intrusted with such absolute and unquestioning confidence as does a prominent public schoolboy. His opinions are not disputed, no opposition benches are ranged against him; but his lightest utterance carries law with it, and in questions of

right and wrong his behavior goes far to shape the yet pliant dispositions of those around him. . . . These, then, are the dangerous aspects of athleticism. It is liable, if allowed full play, to damage seriously the intellectual interests of a school, without raising appreciably the moral tone, and also to become a hindrance to school government. It is quite obvious, then, that great care should be taken to control this development of school-life. It should be looked upon as ever tending to form an excrescence."

Mr. Littleton next proceeds to inquire how the evils of excessive athleticism may be diminished. A boy places but little reliance upon any representation of the teachers as to the unworthiness or secondary claims of athletics in comparison with proper educational objects. "He looks upon them as a class bound to preach such doctrines in the position they hold, and that it is only to be expected they should do so; but as for really thinking that they are right, when as it appears to him the whole of England is the other way, that he can not bring himself to do." Here is the difficulty; the motive power is the public interest. "That motive power is the consensus of fashionable opinion which acts externally on the feelings of the school and produces such results." But, as it is futile to try to correct public opinion, the only way is to prevent its taking effect by withdrawing the boys from its influence. It is in the power of the authorities to prevent those public contests which kindle such widespread public enthusiasm, when the interest and applause of multitudes are presented to the boys in their most imposing and dazzling form. That is, intercollegiate regattas and athletic contests of all sorts, which draw out great masses of excited people, had better be avoided in the interest of sound education.

But, while the prestige of athleticism might be diminished by guarding in this way against external influences, Mr. Littleton recognizes that the plan would have to be supplemented by agencies of a very different character. The school-work itself must be made more attractive. He sees that there is a very important change in the higher education of late years, which is not without promise of counteraction to the excessive devotion to sport. This change in the objects and methods of the school is thus described: "Certain conditions have given birth to a now widely-accepted theory of education, which in all probability will effect still more marked alterations than it has hitherto. The conditions are these: Owing to the increase of population on the one hand, and the advance of learning on the other, we are brought face to face, not only with an increasing number of subjects to be learned, but also with an increasing necessity of learning them. Many members of the class from which, thirty years ago, the ornamental men of leisure were recruited, now find that existence has assumed to them a more somber hue; paths formerly open to them are open no longer, and through knowledge alone an access to ease and affluence is to be obtained. Accordingly, the avenues to knowl-

edge have been made smooth, and everything invites the unwilling to learn. The results of many years' unintermittent labor are presented in a compressed form in every description of hand-book and pocket-primer, for it is only permitted to a comparatively few to remain ignorant and be content therewith. The field of knowledge has thus been greatly extended and opened out, and a great diversity of subjects have been grappled with, in one way or another; and, in spite of the fact that much of this great movement produces a paltry caricature of learning, new interests have been excited and minds stimulated which would have lain stagnant before. The managers of the various seats of education have roused themselves to supply the needs of the time and extend their resources; and they now present to the public a programme far broader and more inviting than that of a quarter of a century ago. In this way various special lines of education have been more widely adopted, and their adoption has influenced the purely general education, with this result: Men now perceive that boys' minds are almost infinitely various, and that knowledge of various sorts must be presented to them in various ways—anything to awaken interest and encourage *voluntary* intellectual effort. Now, it is from the development of this theory that I think we may expect results having an important bearing on the matter in hand. The introduction of subjects likely to attract boys' interest and the general idea of teaching them by exciting that interest tend to upset the notion that work is valuable *per se* quite independently of the subjects worked at. It must be admitted that this notion has been allowed every chance. Men have aimed at educing solid effort by a curriculum of study which could only be attractive to a select few. Let us hope that the idea has really had its day, for, besides being, as many now think, comparatively useless in itself, its effect on an overgrown athleticism is positively pernicious. So long as the graver occupations of a boy's life are slavish and detested, he will throw himself heart and soul into any kind of amusement, and set himself to find his only happiness therein, while all knowledge, all that is either useful for practical life, or merely refining in itself, he will vaguely think must be in a way dismal; his view of it will be colored by the memory of the toilsome and sterile hours he has spent with his books. And, even if he is forced to learn something, such knowledge as he gains will be unproductive; he has no affection for it, and does not care to impart it. It is remarkable how many men seem half ashamed even of such useful knowledge as they do possess. If boys' minds are to be elevated from athletics to anything higher, it will not be by such methods as these."

The change of method which Mr. Littleton regards as hopeful consists, first, in modernizing the curriculum of studies, and introducing into it subjects less repulsive than those now in vogue, and which are capable of exciting a readier and stronger intellectual in-

terest. He would strengthen what is technically called the "modern sides," by incorporating various sciences and the living languages into the schemes of study. Subsidiary to this fundamental improvement several other resources are thus referred to: "But the movement has not stopped here. A further and most satisfactory result is noticeable in the recent establishment of workshops under proper control, where boys can gain some idea of the value of manual labor, and the respect due to careful handicraft. Museums too are encouraged, since they help in extending the front, so to speak, of the intellectual interest presented to the boys, and so increase the chance of alluring a greater number to pursue knowledge for its own sake. For those who know the natures of average boys know that the process of leading them to learn is in reality a process of allurement. Thousands of boys have a strong instinctive antipathy to intellectual effort; their point of view with regard to it has been modified; and if the attempt is made abruptly it will be ineffective; they suspect some sinister design, not knowing yet that what they are being led to is beautiful for its own sake, and capable of making them useful members of society. And, to further this innocent deception, such things as debating societies are valuable. They may induce an intellectual activity in quarters where there is often a marked tendency to stagnation, and stimulus may be given to thought, arrangement of ideas, and the hearing and imparting of facts, without aid of lexicons or fear of the ferule. But they are not often made to serve this purpose without considerable efforts being made toward sustaining them after they have once started. Transitory conditions may start them, and then generally a crisis supervenes demanding great care. Supposing, however, that this has been survived in safety, the society is liable to change its character. The debating element in its constitution is seen to lose prominence, and a club is formed of boys elected for their popularity, an aggregation of the influence of the school. There is of course a natural tendency to this, and the result is not unsatisfactory. Such a club embraces a class of boys whom a purely literary or debating society would probably exclude. They join it without the least intention of learning anything; but its usages should compel them, by means of debates, to take a livelier interest in rational subjects and enlarge their mental horizon. But there will very likely be room then for a purely literary society of a less compound nature, to coexist side by side with this club, and provide solely for the more studious portion of the community. For it can hardly be expected in any school that a club, with members elected for popularity, should coincide with another consisting of the scholars and the foremost devotees of learning.

"Many schools also publish periodicals, written and supported by the boys themselves, and these periodicals are of two characters: those devoted wholly to the record of athletics; and those which, besides

being athletic journals, contain original compositions, both poetry and prose. They serve a useful purpose, as well as the societies, by fostering a mental activity among the class hardest to reach. Many a young athlete must have first been induced to exert his immature powers by writing (say) some reflections on certain aspects of football. The theme, doubtless, is somewhat humble, but he has to do his best, as his readers know the details of the question thoroughly, and will express their opinion as plainly as any weekly review. Perhaps he learns for the first time that having ideas is not the same thing as expressing them. But to promote the existence of journals which deal entirely with the school-games is dangerous. A very definite impression is made on the younger boys, if they are led to think there is only one subject on which their superiors think it worth while to express their ideas. An indefinite prestige is added to any subject, and still more to any name, by being immortalized in a few lines of letter-press, and it seems advisable that this glamour should not be thrown around one set of interests solely. The periodical should have a double character, and ought to act in the same way as the two kinds of debating society existing together; the serious portion of the journal would be the field for the literary effort of the studious and the scholar-like, as the literary society would be for their speeches; while the athletic records can teach athletes to write, just as the debates of the fashionable club would help them to speak."

But again, and in another aspect, Mr. Littleton sees that the question is complicated with outside influences. If public opinion strengthens excessive athleticism on a grand scale, by making it a popular show, the feeling for it is also fostered in the family, so that boys' heads are filled with it before they enter school. Here, also, as in many other matters, the weakness and folly of parents have a baneful efficacy in hindering educational improvement and school reforms. On this point it is remarked: "But what is to be said about the life at home? It is a farce to talk of debating societies and the like being available to combat this or, indeed, any other difficulty, so long as boys are sent to school primed, since the nursery, with the one idea that amusement is to be sought at school, and that a boy, if he is worth anything, will find it and make the most of it. The efforts of the professional teachers depend, to a great and generally unappreciated extent, on the co-operation of the parents. Meantime, the mischief is frequently done before the school-training begins. It is not very uncommon to find parents who have sent their son to a fashionable school, previously urging him to keep out of debt and make suitable acquaintances, but at the same time warning the poor child against getting too fond of books. Others, no doubt, are more cautious; but the traces of a genuine stimulus hence toward useful work are lamentably rare, and more rarely still are habits of reading encouraged away from school. Not, however, that we need always postulate reading; we may, perhaps,

confess to a strong bias in its favor; we may recollect that discerning men, when the great literary preëminence of Germany is talked of in their presence, have been wont to point with pride to the broad diffusion of pure literary interest through the upper strata of our society, quite independent of any profession or hope of emolument, and challenge one to find the like in foreign lands; and we may judge from such indications as I have spoken of, and doubt if this superiority is as noticeable as ever. Again, we may feel, besides this, that to bring up a boy in ignorance or contempt of reading is, from many points of view, a deplorable error. Non-reading parents, we may think, do not know what it is they are keeping from their son; how they are depriving him of a great safeguard against temptation in his youth, and a lasting resource against weariness in his maturer age. They can not know what it is for harassed minds to be able to turn to literature and find there a refreshment that never fails in the midst of petty worries or heavy affliction, and, not knowing this, they tell him that he can do without reading, as if it were a thing of little worth. All this we may feel, but it is only a matter of opinion; our point of view just now may be thought peculiar; anyhow, we readily admit numberless other methods of awakening in a boy a genuine interest in one, at least, of the multitudinous forms of intellectual life which expand daily around him. There is no excuse for sending a boy to school with a disposition framed for frivolity, with idle instincts to be freshly infused by every holiday-time; whenever it so happens, something has gone wrong which need not have done so, and yet so it happens in thousands of cases every year. Parents do not do this designedly. It is not easy to realize at once that a boy requires incessant support if he is to overcome his natural antipathy to learning anything, and certainly they have very little idea what are the dangers attendant on an idle school career. Anyhow, the result is an influx into so many schools of boys bred up to a spirit of inertia, and encouraged hence to nourish it. From this unwise preparatory training the unruly growth of athleticism has sprung."

THE MATAMATA.

By E. SAUVAGE.

PIERRE BARRÈRE, in an essay on the natural history of the equatorial possessions of France, written in 1741, described a tortoise of a singular form which the Indians of Guiana called the *raparara*. It had, he said, a long, wrinkled neck, from which hung small membranes, ragged or slashed like a fringe; its head was flattened and triangular, and ended in a kind of trunk shaped like a quill-

pen; and the upper part of the shell was furrowed and marked with large knobs. This concise description gives a fair idea of the principal features of the tortoise which is illustrated in the cut. It is hard to tell which most attracts attention, the large, triangular, depressed head,

THE MATAMATA (*Chelys matamata*).

the mouth extending behind the ears, or the doubly furrowed back with its three knobbed ridges. The head ends in a small, movable snout; the eyes are very small and set far forward; the sharp jaws are covered with a horny sheath. The neck is thick and bristles with tubercles, and from each side of it hang the ragged membranes which float in the water. The scales of the carapace are raised into promi-

nent knobs, and from the tip of each knob furrows radiate in every direction. The tail is short and obtuse. The long and hooked claws are attached to paws which are somewhat palmated and of moderate length. The carapace is beveled to give play to the hinder limbs, and the cuirass is narrow and hollowed by a deep furrow in its after part. The upper part of the body is for the most part of a brick-red; the cuirass, not so deeply colored, is marked by blackish marblings. According to M. Spix, who has observed the living animal, the scales of the carapace are of a maroon brown, with radiating streaks, and the lower part of the head and the most of the members are of a greenish yellow pricked with brown. This tortoise is a native of the Guianas, and lives in stagnant waters and half-dried marshes. Except at the time of laying its eggs, it hardly ever goes to the land. Immersed in the mud, which it is not unlike in color, it lies in wait for the creatures which are imprudent enough to swim near it. The ragged membranes, floating in the water like worms, attract fish seeking for food. When a suitable prey passes within reach, the head which has been bent to one side instantly darts out as if it were hurled by a spring, and the victim is quickly buried in the huge throat of the reptile.

This tortoise, described by Barrère as the raparara, has been called by Schneider the Sinibrian tortoise. Bruguibre, in his "Journal d'Histoire Naturel de Paris," has given it the name of *matamata*, which is generally accepted by modern zoölogists. The only species from which the genus *Chelys* has been formed lives in the Guianas; and the individual, which is now to be seen in a living state in the museum at Paris, was captured there by the French explorer, M. J. Crevaux.

FROST-PHENOMENA IN SOUTHERN RUSSIA.

SOME few people may perhaps have remarked and remembered an unusual meteorological phenomenon which occurred in London last Christmas night. We had had several weeks of hard frost, and the cold on Christmas morning was rendered more piercing than ever by a bitter east wind, though indications of an approaching thaw were not wanting. About the middle of the day, snow began to fall; but in the evening this changed to rain, which froze as it came down; and by ten o'clock not only were the pavements covered with a sheet of slippery ice, but walls, lamp-posts, railings, etc., were all glazed in like manner. Every object upon which the eye rested glittered and sparkled, looking as if it had received a sudden coating of glass; while from every roof and ledge hung a fringe of icicles, some of them as much as a foot in length. In the morning, the whole fairy-like appearance had vanished.

This sort of thing does not often occur in England, and, when it does, it lasts but a few hours at the outside; but, in certain latitudes, the requisite meteorological conditions sometimes continue for days and even weeks together, and then the results are most disastrous. The rain continues to fall, and to freeze as it falls; and the crust of ice grows thicker and thicker, until tall trees and miles of telegraph wire are broken down by the enormous weight. Fortunately, the phenomenon is generally arrested before it attains this extreme degree of development, and, when it does occur, seems to be almost entirely confined to the steppes of Southern Russia.

It may be remembered that, during the winter of 1876–'77, frequent references were made in the newspapers to the state of the South Russian telegraph lines, many of which, especially those in the governments of Kherson and Taurida, were rendered perfectly useless for weeks by just such an accumulation of ice as we have been describing. A German gentleman, Herr Bernhard Bajohr, happened to be journeying from Nicolajew to Berislaw about the middle of December, when things were at their worst; and as the phenomena are seldom seen so fully developed, even in Russia, as they were at that time, it may be worth while to give some account of what he saw. His road lay between two telegraph lines; one the Indo-European, the other that of the Russian government, so that he had ample opportunity of observing and comparing the different effects produced upon the two. But, before describing these, we must say something as to the meteorological conditions required for the formation of this peculiar ice-incrustation.

In long-continued and severe frost, the earth is frequently chilled to a considerable depth, and to such a degree that it absorbs the warmth from the lowermost stratum of air, which becomes icily cold in consequence; while the trees, buildings, etc., within the cold stratum naturally share the surrounding temperature. This cold stratum may be from twenty to forty feet in thickness, while the air above is many degrees warmer. If rain fall from these warmer regions, though there will not be time for it to freeze during its short passage through the colder air, yet, directly it touches the ground or any other ice-cold substance, it will congeal and cover it, whatever it be, with a glaze of transparent ice, as noticed above. Herr Bajohr observed that, when the ice first began to form upon the telegraph wire, it was in the shape of a cylindrical roll, which instead of hanging from the wire, or being crystallized round it, as one would have expected, merely rested upon it, the wire touching its lower circumference only. As rain continued to fall, the cylinder increased in size, until its diameter measured from half an inch to three inches. This was the first stage of development; but then the intensity of the cold abated somewhat, and the rain which was still falling, instead of freezing the moment it touched the roll of ice, had time to trickle over it, and form long rows of icicles,

remarkable for their regularity and uniformity. This was the second stage, and the heavily laden wires looked like nothing so much as gigantic combs.

It is not often that the third stage of development is reached; but it does sometimes happen that, when icicles and cylinder have attained their full size, the rain ceases, the sky clears, and the sun begins to shine. Its rays are much too feeble to melt the ice; but they pass through it to the more sensitive black wire within, whose temperature is so much raised that it melts the particles of ice in immediate contact with itself; its cohesion with the heavy roll of ice above is destroyed, and the latter, unable any longer to maintain its balance, twists round so as to describe a semicircle and exactly reverse its position. The icicles now stand up in the air above the wire, while the roll hangs below it; and, if there should be more rain, a second row of icicles will be formed opposite the first, producing a striking resemblance to the backbone of a fish, which is rendered still more perfect if there happens to be any wind blowing in the direction of the telegraph line, as in that case both rows of icicles will be slightly inclined toward the wire in the same direction. This last stage of development may also be attained without rain, should the sun have sufficient power to melt some of the ice; the water from which will then trickle down to the under-side of the roll of ice, and there form icicles in a similar manner. As the sun gains in power, the wire increases in temperature, and melts away more of the ice from within; the icicles, borne down by their own weight, drop lower and lower, until the wire reaches the extreme points of the upper row, when of course the whole congealed mass soon drops off.

Herr Bajohr noticed that the effect produced by this phenomenon on the two lines of telegraph differed considerably, that of the Russian government suffering far more than the other. The posts of the Indo-European line are of iron, and the conducting-wires are thick and strong; and, though the wire was considerably stretched, it had on the whole borne well the immense strain put upon it. Here and there, where the line made a bend, the post at the angle, firmly fixed though it was, had sometimes given way, and, wherever this was the case, several of the neighboring posts had also succumbed. But the government line, with its oaken posts and four thin wires, running parallel with the Indo-European line, presented a much more dismal appearance. The oaken posts, somewhat crooked to begin with, had not all proved strong enough to sustain the weight of the four heavily laden wires, and in some places had broken down altogether; while, where they remained erect, the wires were either broken, or completely weighed to the ground by the burden laid upon them. All the posts, both iron and oaken, were covered on the windward side with a crust of ice several inches thick, reaching from the ground to the insulators, where it joined the ice on the wires; and in this way insulation was

destroyed, and each post was converted into a conductor, down which the electric current passed into the ground. This was especially the case directly the extreme severity of the weather abated and the ice became less dry. But the iron posts had this marked advantage over the wooden ones, that, whereas the latter kept their coating of ice for weeks, these others threw it off directly the sun began to shine. Being black, they absorbed heat more readily, and, by melting the inner surface of the ice, soon caused the whole to crumple up and fall off.

In conclusion, it remains for us to say a few words as to the effects of this remarkable frost-phenomenon upon the vegetable world. Trees are everywhere scarce in the steppes, their cultivation being attended with very great difficulty; nor is this to be wondered at when one considers the various climatic influences to which they are subject. During the winter of which we have been speaking, every tree, every branch, every smallest twig was incrusted with ice one, two, or three inches thick; and accordingly the trees in the town of Kherson, chiefly white acacias, lost nearly all their branches, while many of the smaller ones were completely crushed to the earth. Of the fruit-trees, all of which looked as if they were made of glass, some suffered more, some less, according to the character of their growth. The apple-trees and apricots for instance, with their spreading horizontal branches, were for the most part quite broken down; while the more erect-growing pear-trees and cherries had maintained their balance better and suffered much less in comparison.—*Chambers's Journal.*

SKETCH OF CARL RITTER.

CARL RITTER was born at Quedlinburg, in Saxony, the birthplace of Klopstock, on the 7th of August, 1779. His father was physician in ordinary to the Abbess of the convent in that place, and was a man of noble character and gentle disposition who was held in high esteem by his fellow citizens. He died in the prime of life and left his widow destitute, with five children, Carl being then five years old. The helpless situation of the widow, a well-born, refined woman, awakened general sympathy. Salzmann, who was about establishing a school for young children in Schnepfenthal, heard of it and determined to adopt Carl as a gratuitous pupil and as his first scholar. Carl found this a second home, and remained at the school eleven years, or until it was time for him to go to the university. It was in this lovely Thuringian town that, looking upon the manifold shapes of mountain and plain, wood and field, he received his first impressions of the relations which exist between the configuration of the

earth's surface and the life that is developed on it. Modern languages and the arts and sciences were the more prominent subjects of study at the Schnepfenthal school, the classics receiving a secondary consideration.

While here, and with no definite prospects for his future after he should leave the school, Herr Hallneg, a partner in the wealthy house of Bethmann at Frankfort-on-the-Main, visited the institution at Schnepfenthal, and was so prepossessed by Ritter's appearance that he offered to support him while he continued his studies, on condition that he should engage afterward to teach in his house. So Ritter in his seventeenth year went to the University of Halle, and was matriculated as a student in branches relating to finance, in connection with which he gave especial attention to statistics. He made many friends while at the university, and at the age of nineteen went into Hallneg's house as a private tutor, and there formed a friendship with the youngest son of the rich merchant, his pupil, which endured through his whole life. Several distinguished men were accustomed to visit this house, and intercourse with them had such a stimulating effect upon the young teacher that his abode there may be regarded as having been in a certain sense a prolongation of his university career. Chief among these men was the naturalist Sömmering, whose geniality and liberal knowledge gave him great influence. Another was Alexander von Humboldt, who made a deep impression on Ritter's mind. Full of enthusiasm, Ritter wrote to his old teacher Gutsmuth: "It has now been eight days that I have enjoyed the happiness of being associated with Alexander von Humboldt. He is one of the most interesting men I have ever seen. It was my privilege to become acquainted with him on the first evening of his visit, and I have since enjoyed most precious hours in his society." At the same time Ritter was devoting himself to a diversity of studies, particularly to the pursuit of those branches, such as the classical languages and literatures, to which he had previously given a lesser share of attention. For this purpose he attended the gymnasium at Frankfort, and sat on the school-bench with his pupil Hallneg. His inclination toward geographical and historical studies did not, however, cease to preponderate; and, in order to make himself fully at home in these subjects, he not only read the most important works upon them with great care, but also made frequent excursions in the neighborhood of Frankfort for purposes of independent observation. A happy skill in drawing the objects of interest in the landscape was of great help to him.

His first geographical work, consisting of six maps of Europe, was published in 1806; it was followed in 1811 by a Geography of Europe in two volumes. These two works, his first efforts on a field in which he was afterward to be a master, already gave indications of that comprehensive grasp of geographical principles for which he afterward became distinguished.

In 1807, accompanied by his pupils, he started on the first of a series of journeys undertaken for purposes of study and investigation. This time he visited Italy and Switzerland. In Switzerland he formed the acquaintance of Pestalozzi, Pictet, and De Candolle, living in Geneva a year. In Italy he enlisted Thorwaldsen, Overbeck, and Cornelius among his friends. In 1813 he went with his pupils to the University of Göttingen, where he had an opportunity to make use of the treasures of the library for his great geographical work. He still regularly visited the lecture-rooms of the professors and attended the different colleges. After two years at Göttingen he went to Berlin, and there, in 1817, published the first part of his "Erdkunde im Verhältnisse zur Natur und Geschichte des Menschen, oder allgemeine Vergleichende Geographie als sichere Grundlage des Studiums und des Unterrichts in physikalischen und historischen Wissenschaften (Geography in Relation to Nature and the History of Men, or General Comparative Geography as the Secure Basis of Study and Instruction in Physical and Historical Knowledge), a work in which the treatment of geography was completely transformed, and the study was raised to the rank of a true science. This part included Africa and a portion of Asia. A year afterward appeared the second part, in which Asia was concluded. In this work he delineated the form and surface of the earth, in its horizontal and vertical features, with great accuracy. Taking a comprehensive view, he considered the peculiarities of the different parts of the earth's surface in their relations to each other and to the earth as a whole, and regarded them as the underlying basis of all living existence, and the foundation and condition of the development of single peoples and of the whole human race in its manifold changes of relation.

In 1819 Ritter was appointed Professor of History in the gymnasium at Frankfort; but he soon exchanged this position for a higher one, for in the next year he accepted an invitation to Berlin, where he was appointed to the chair of geography in the military school and the university. Here begins the second great division of his life, in which he could enjoy both in the department of scientific research and as a teacher the ripe fruits of his earlier activity. Berlin, where a new, fresh life was then beginning to beat, where he was associated with Alexander von Humboldt as his hearty friend, was the right place for him to work, and he was fully conscious of it. After Prince Albert became enrolled among his scholars, he was introduced to the circle of the Crown-Princes, and afterward to King Frederick William IV., before whom he gave lectures on geography. In 1825 he became director of studies to the Cadet corps, and in 1828 founder and first President of the Berlin Geographical Society.

Ritter was accustomed, during his autumn vacations, to take considerable journeys, which not only gave him mental and bodily recreation, but also assisted in the advancement of his geographical studies.

The most extensive and important of these journeys were to Greece and Constantinople, and back through Hungary; to Paris and Southern France; and to England, Sweden, and Norway. He afterward concentrated his whole attention upon geography, giving up for this purpose all employment that was not connected with it. From 1832 the series of volumes on Asia appeared in rapid succession; the nineteenth volume was finished only a few weeks before his death. With the progress of this work, his fame increased from year to year, and his connections and the influence which he exerted upon the progress of geographical research were extended to all the countries of the civilized world. He became one of the most important personal centers in the whole domain of geographical science, not less on account of the incomparable richness of his knowledge than on account of the living interest which he took in all current questions. In this position he did not fail to receive distinctions of every kind. As a teacher he acquired a brilliant clientage. When he published his first lecture on general geography in 1820, it is said that he had not a single scholar; afterward the largest lecture-rooms were not sufficient to hold his classes, and at Berlin it became the fashion to attend his lectures. As a teacher, and in all his personal relations, he possessed a strong attractive influence. Kramer, his biographer, says that no one ever approached him without meeting the most kindly reception, that he was ready to recognize every honestly meant effort, to encourage, to help with counsel and support. No man ever had less of egotism. His physical condition was generally good through the whole of his long life. He had a strong constitution, which was hardened by exercise in his youth and strengthened by the pedestrian excursions taken on his journeys. The weaknesses of age began to appear in his later years, and, on account of them, he often visited the springs of Teplich with good effects. He made a visit to these springs in 1859, the year of his death, but returned no stronger, and died on the 28th of September. After his death were published his "Geschichte der Erdkunde und der Entdeckungen," 1861; "Allgemeine Erdkunde," 1862; and "Europa," 1863.

CORRESPONDENCE.

Messrs. Editors.

IN a good but caustic review of Mr. Mallock's book—"Is Life worth Living?"—you make use of a sentence which would seem to reflect on all alike who are engaged in the study of theological problems: "We have here the last brilliant exploit of the theological mind in its warfare with modern science." Permit me, as a student of theology and a lover of modern science, to read you a short lecture. Many of the young ministers to-day are firm believers in evolution, and preach it. This theory is by no means a hindrance in our study of theology, but the best instrument which has so far been placed in our hands. If on our desk the Bible lies, so also do Spencer's "First Principles" and his "Sociology." If we respect and study Jesus, so do we Spencer and Tyndall and Clerk Maxwell. These have a gospel for us—they have a hope. The young theological mind is very far from engaged in a warfare with science; it is anxious, and hoping, for firmer ground than we now have. If science can help us, and it can and does, in making this life more valuable, the future brighter, and ourselves better, we welcome it. We are not troubled about reconciling theology and science; we take what we can in both, after honestly and carefully investigating for ourselves, and then allow them to reconcile themselves. What we have to do with is the truth pure and simple. Some of us will not pledge ourselves to any "body of divinity," either ancient or modern; we will not swear by Bibles, old or new, nor believe all the spirits, either in the Gospels or the biologies. The writer of the preface to the American edition of Spencer's "First Principles" tells us that his hope is in the young men. Many of them are with him. We now only ask you to remember this, and let us investigate in our own fields, mindful of the fact that we are each doing our best to find the truth. We are side by side oftener than we imagine, even if some college presidents will not see it. None are so blind as those who will not see.

It would not be out of place if in the "Monthly" you would give an article, now and then, bearing *directly* on the theological questions—the higher theological questions, not the petty disputes of the sects.

You have our hand.

A YOUNG THEOLOGIAN.

KEENE, N. H., *January* 21, 1880.

THE AGE OF ICE.

Messrs. Editors.

AN article under the above title, published in the October number of the "Monthly," appears to have brought upon its author the charge of plagiarism. But his own note with the accompanying editorial, published in the February number, not only completely exonerates him, but actually converts the charge into an encomium. For the writer of the article in question can scarcely fail to appreciate the compliment of being charged with borrowing, from so reputable an author, ideas which prove to have been made public before the able work of Mr. Croll had seen the light.

But, if the accusing party had carefully and understandingly read the article of Mr. Norton as well as those which he charges Mr. Norton with plagiarizing, he would never have made the charge. For he would have discovered in the former article statements quite excusable, when the date of their writing is known, but which would never have been made had Mr. Norton read either the work of Mr. Croll or the articles of Mr. Merriman. The object of the present writing, however, is neither to vindicate nor to criticise.

But, since the "Monthly" is almost solely relied upon by so many readers as an exponent of the latest scientific discoveries and opinions, the publication of Mr. Norton's article, so long after it was written, seems liable to mislead this class of readers. The conductors of the "Monthly" may not, therefore, deem it inappropriate to give place in their columns to a very brief statement of the points in which the article is likely to convey an erroneous impression:

1. In the published abstract the author says: "The southern hemisphere has at present a winter of 187 days and a summer of 179 days. We may justly infer that during this winter more snow and ice accumulate than the shorter summer is able to melt."

In the lecture this statement may have been accompanied by such an explanation as to prevent a misconception; but, as published, it must leave on the popular mind the impression that, because the summer is shorter, therefore the heat received from the sun is less—an impression which many have received; whereas it was long since shown that the earth receives from the sun exactly the same amount of heat from the

vernal to the autumnal equinox as from the autumnal to the vernal, whatever may be the position of the apsides, and whatever the eccentricity of the orbit.

2. In speaking of the variation in the eccentricity, the author says: "There is one more factor in this problem which must be considered, and that is the periodical variation in the eccentricity of the earth's orbit. Sometimes the line of the apsides is longer than at other times."

I am at a loss to account for this last statement. The author must have known that the mean distance of a planet from the sun is one of the two invariable elements of the planetary orbits. Of course the line of the apsides, which is the major axis of the orbit, and therefore twice the mean distance, can not vary. The eccentricity is increased or diminished by diminishing or increasing the *minor* axis, the *major* axis remaining always the same.

3. In discussing the displacement of the earth's center of gravity by an accumulation of ice at the pole, it is said, "Now push the center of gravity 2,000 feet toward the north, and the Arctic Ocean would be so much deeper over the pole, and the water would be about 1,000 feet deeper at the latitude of 45°. To accomplish this result, we must calculate that the space within the Arctic Circle was covered by an ice-cap averaging, perhaps, 8,000 feet in thickness—an entirely supposable case."

By calculation, I find that, if all the water to form this ice-cap were taken from within the Antarctic Circle, and if the density of ice were equal to that of the earth, the above statement would be approximately correct; but, allowing for the difference of density, the cap must be more than eight miles in thickness; and, if the water to form the cap were taken equally from all parts of the earth's surface, the thickness must be more than sixteen miles.

Perhaps it should be said, however, that, according to Mr. Croll, no such amount of displacement is required. He estimates that the transfer of an ice-cap two miles thick from the southern to the northern hemisphere, which would displace the center of gravity about 380 feet, would satisfy all the demands of the glacial phenomena.

4. But, if Mr. Norton's article should be received as an exponent of the present views of those who advocate this theory, it would be most seriously misleading in the date to which it refers the *age of ice*. It is said: "Unless astronomical calculations fail, the last great summer of the northern hemisphere commenced some 6,500 years ago. When it began, northern America, Europe, and Asia were frozen and deluged. The Arctic Ocean extended to a line south of the present bed of the Great Lakes. The Alps and the Altai were also southern boundaries of this ocean. Europe was the home of a swarthy, dwarfish race, who hunted the aurochs and great hairy mastodon at the foot of the glaciers that then half overflowed the continent."

Thus the *age of ice* is referred to the last mild aphelion winter, when the earth's orbit was but slightly more eccentric than at present. But both Mr. Croll and Mr. Merriman, from whom Mr. Norton is accused of plagiarizing, refer the glacial epoch to a period of great eccentricity, from 80,000 to 240,000 years ago.

Indeed, the warmest advocates of the great year theory freely admit that, with the eccentricity no greater than it has been at any time within the last 80,000 years, the age of ice could not have been the result of such a cause. It scarcely need be added that some refer the ice age to a period of still greater eccentricity, some 800,000 years ago

M. LYFORD.

WATERVILLE, MAINE, *January* 26, 1880.

ARSENIC IN KINDERGARTENS.

Messrs. Editors.

THERE has been of late, in the local newspapers, a good deal of discussion, *pro* and *con*, concerning the merits and demerits of the Kindergarten system. Without presuming to decide whether the system is good or bad, I wish to bring under the notice of your readers a simple fact in connection with it that is of more than local interest. A friend of mine in Pittsburg, who has a little daughter being instructed (or amused) in one of the Kindergartens here, recently handed me some pieces of a green-colored paper which the child brought home from the institution, and told me that one of the amusements of children in such institutions was to cut figures out of various colored papers and fashion them into designs of different kinds, the aim of such amusements being to instruct in distinguishing various shades of color and differences of form. The green paper above mentioned I have very carefully examined, and I find that it contains an abundance of *arsenite of copper*, which most people nowadays know to be poisonous. In these days of reckless assertion by pretended men of science, it may be well to fortify my statement, and I accordingly send you two hermetically sealed tubes, one of which contains a mirror of *metallic arsenic*, and the other a ring of crystals of *arsenious acid*, both of them derived from the green paper, of which I also send you a sample. Several mirrors were obtained from a fragment of paper half the size of the piece inclosed, and material enough was procured from it to produce several more. The crystals can be recog-

nized, under a three-hundred power of the microscope, as octahedra. Knowing well that such paper is used in all other Kindergartens throughout the country, and knowing also the habit of children putting everything available in their mouths, and especially of swallowing paper, I think the use of a sort colored with an arsenical pigment deserving of the severest reprehension. You may, if you please, show these tubes to any of the able chemists of your city, or describe them as you may see fit.

Yours truly,

GEORGE HAY, M. D., *Analyst*,

ANALYTICAL LABORATORY, 45 DIAMOND ST., ALLEGHANY CITY, PA., *January* 16, 1880.

EDITOR'S TABLE.

"*LET WELL ENOUGH ALONE.*"

A GOOD illustration of the tendencies of officialism in education, as well as in politics, is afforded by the recent inaugural address of the new President of the New York Board of Education, Mr. Stephen C. Walker. He said he had formerly been opposed to the policy of taxing the people to sustain academic or high-class education. But no sooner does he find himself in the official saddle than all doubt is dissipated, and he becomes the eager apologist of things as they are. And this is the more remarkable, as he betrays a lurking consciousness that there is a good deal hereabout that will not bear examination, and of which the less is said the better. He admonishes some people that they had better have a care, and not push things much further, as there may come a day of reckoning. Therefore he urges quiet and acquiescence, and deplores all excitement and agitation. A certain questionable policy being consummated beyond what its promoters could have ever dreamed, he thinks the rule should be now, "Let well enough alone." Mr. Walker is reported as saying: "We not only have two colleges, whose expenses are met by general taxation, with *curricula* embracing every known subject of academic instruction, but, in the course of study of our grammar and primary schools, the subjects presented number fifteen or twenty, and, of course, embrace many which are neither essential nor elementary. Never having been able to give full assent to the arguments which are claimed to prove the propriety of making academic education a public charge, I am ready, and even eager, to accept the present situation of affairs, and to say to the champions of what is called higher education, and to the less eloquent and active advocates of elementary instruction, let well enough alone. I foresee dangers in agitation and disturbance. I see much good in things as they are. If those who sincerely believe that the Government should be so parental and munificent as to place within the reach of every aspiring lad the means of the most ample technical or professional education will only rest content with the large measure of success they have already gained, with the crowded seats of advanced learning endowed beyond all dreams of private munificence, by legislation, which subsidizes for their support the property, real, personal, and mixed, of the whole Commonwealth, they will not hazard the attainments already made. In pushing for more there is, in my judgment, a possibility of arousing a power in the community, of great weight by reason of its wealth, its clear judgment, its conservative and logical methods, which shall bring all the force of argument and capital against the existence, at public expense, of academic education in any form."

Having got two colleges, embracing every known subject of academic instruction, and grammar-schools devoted to fifteen or twenty subjects which are

neither essential nor elementary, and endowed beyond all dreams of private munificence by legislation which subsidizes for their support the property, real, personal, and mixed, of the whole Commonwealth, for all of which he has never seen sufficient reason, Mr. Walker thinks we may now rest and be thankful. There have been demands that something should be done to make education more practical in the direction of applied science and industrial art. But Mr. Walker says: Be quiet; these things can only come in with a popular boom. This is his language: "It may be that, as a result of one or all these demands, we shall see the time when the turning-lathe and the sewing-machine shall be parts of general school supplies. The point I make is, that agitation and discussion of this subject are not incumbent upon us, who are called to administer the school system as we find it, not to revolutionize its fundamental principles or work experiments. When the time comes for such changes we shall all hear of it. It will be a voice as of the sound of many waters. The school system and its methods and subjects of instruction are surrounded by almost constitutional guarantees. The people created and cherish this system and these methods and the existing modifications thereof." Now, we respectfully suggest that, if President Walker proposes to keep things placid, he must be a little more circumspect in his statements, and not give occasion for indignant protest. It is not true of the school system under his jurisdiction that the people created it "and the existing modifications thereof." Those "modifications" were never called for or authorized by the people. The school system of New York has been revolutionized and perverted from its original purposes, and that not by popular initiation and approval, but by manœuvring and indirection, by wire-pulling and huggermuggery. It has been prostituted to ends never contemplated by those who established it and have sustained it, and this has been done in express defiance of the known convictions and wishes of the people. President Walker probably knows this, and hence his apprehension of a popular explosion, and his exhortations to a cautious and gingerly treatment of fundamental questions. On the contrary, we think the subject can not be too often and too thoroughly ventilated.

The reader is referred to a previous article in this "Monthly," which shows that the New York school system was founded to supply elementary instruction to those unable to obtain it in pre-existing schools. But, with the progress and diffusion of knowledge, and especially of practical scientific knowledge that bears upon the common avocations of life, there grew up a popular demand that our common-school system should do something to qualify boys for industrial pursuits. To give effect to this widely expressed desire, it was proposed to establish in connection with the public-school system a high school of technology and practical science, to help boys who were expected to learn trades and follow industrial occupations. It was submitted to a popular vote whether such an institution should be organized, and its distinctive and limited object was printed upon each ballot. The people pronounced by a large majority in its favor, and the "Free Academy" was the result.

But the object of this institution was never honestly carried out. Its faculty were ashamed of its vulgar "utilitarian" purpose; a "Free Academy" had no status among dignified institutions, and its officers did not cease their exertions till its object was abandoned, and the concern was transformed into a "regular college." The Free Academy was killed, and a new charter was obtained, instituting the "College of the City of New York."

With this "modification thereof"

the people had nothing to do. They were never offered a chance of expressing their opinion of the repudiation of the plan they had formally ratified. It was diverted from its objects, without consulting them, by ring-management; and, as the city had got a college for boys, the cry was raised that there must be another for girls also; and the Normal College was the result.

There was no mistaking the character and object of this covertly managed revolution in the policy of popular education in this city. When the thing was done, all disguise was thrown off. As we have stated before in these pages, but which may now be pertinently recalled, Judge Larrimore, President of the Board of Education, gave an address explanatory of the new situation. The school called for by the people was contemptuously repudiated in its theory and object. The new institution was proclaimed as of the old order of colleges. The speaker went back to the middle ages to get his ideal of a college, and defended classical studies, as entitled to the leading place, in opposition to the claims of science and modern studies. How far he appreciated the idea which the people had tried to embody in the Free Academy was shown by the fact that, when an influential work on education, that has been translated into all civilized languages, was quoted, he sneeringly retorted that it was written by an *engineer*.

Had the design of the Free Academy been carried out in good faith, its benign results to education in this city and this country would have been great. A generation has passed since the people pronounced for an advance in industrial education; and if the plan had not miscarried—if they had not been cheated out of it—the salutary influence upon the lower schools, and the consequent benefits to the community, would have been incalculable. But this retrogressive step has been fatal to our educational progress. The classical college at the head of our system has reacted to obstruct reform in the primary schools. Of the way this influence is exerted we have a fresh illustration. The new President, notwithstanding his solicitude to let things alone, can not refrain from meddling. He was made chairman of the Board of Trustees of the City College, and in his address he said that "the college entrance examinations were not exacting enough." That is, the screws must be put on to the lower schools to force more vigorous exertion on the part of boys with reference to the system of instruction pursued in the classical institution.

CONANT ON INTERNATIONAL COPYRIGHT.

It is surprising how English ardor on international copyright cools as Americans begin to draw the distinction between the rights of British authors and the claims of British publishers. As long as these were mixed up, the case against us was strong, and we were very frequently reminded of the turpitude of our piratical practices. But when it began to be said here, seriously, We will yield the English author his just demand, and pay him for his literary property, but his foreign publisher we will not pay because he has no just claims upon us, then we hear a good deal less of foreign denunciation, and international copyright ceases to be urged, or much discussed.

Mr. S. S. Conant, of New York, was asked to write a paper for "Macmillan's Magazine," giving the American view of the subject. He complied, and furnished an able article, moderate but decided, and discussing the question with a view to its practical settlement. He recognized the urgency of the question, and took the ground that the full rights of English authors should be accorded and secured by law, but that we in this country must be permitted to manufacture their books. He showed

that the foreign book-maker has no rights that such an arrangement would violate, and that equity would be completely gained if the foreign author was required to make his bargain with some American publisher. There are American reasons for this policy, the force and validity of which Americans must be left to judge of; but justice will be satisfied when the foreign author is put upon the same basis as the American author.

A reply or at least a rejoinder to this article, by an English lawyer, followed it in the same number of the Magazine. Mr. Conant had said that the need of some adequate copyright arrangement between the two countries was pressing; his critic undertook to be very sarcastic at this, declaring that leading American publishers were now beginning to suffer from the carrying out of their own vicious system, and had suddenly discovered that the case is pressing. He said that he saw no particular symptoms of urgency in England, and doubted if the Americans were very eager about it, so that on the whole the matter might as well be at present let alone.

Mr. Conant returned a crushing reply to his critic, but "Macmillan" declined to print it. It, however, appeared in the London "Academy." He showed that the quibble over the word "pressing" was aside from the argument, and that that term simply indicated the actual status of the question in both countries. If business had become more demoralized here, under a bad system, than before, it only furnished a more potent reason for remedial action. No change certainly had taken place on this side of the water which could lessen the interest of the British author in international copyright. On the contrary, the system in this country was working out results more and more damaging to foreign authors. As to the state of feeling in England, Mr. Conant showed that her authors at any rate did not share the assumed indifference of "Macmillan's" critic. He showed that the recent Royal Commission relating to home, colonial, and international copyright, gave prominent and earnest attention to the relations of England and the United States with regard to authors and reprints, and that their report bristled with evidences of the interest felt in that country over this question. And, finally, he clinched the case by putting in the recent statement of fifty eminent English authors, not only recognizing the importance of the question, but accepting the American view of it, and expressing their readiness to acquiesce in it as an entirely fair and just arrangement.

So the tables are now turned, and the English publishers, who oppose a measure satisfactory to the parties rightly interested there, and which is the only practical measure that can possibly be carried out here, are now in the position of obstructives, and enemies of copyright. Mr. Conant's pamphlet puts the thing in a nutshell, and those concerned with the progress of the discussion can obtain it by application to Harper & Brothers, New York.

LITERARY NOTICES.

SPENCER'S SYNTHETIC PHILOSOPHY.

CEREMONIAL INSTITUTIONS. Being Part IV. of "The Principles of Sociology." By HERBERT SPENCER. Pp. 237. Price, $1.25.

HAVING paused for a short time in the elaboration of his "Principles of Sociology" to anticipate a portion of the next treatise on "Ethics," Mr. Herbert Spencer has resumed his labors in their regular order, as the volume before us attests. The first volume of the "Sociology"—a work of over seven hundred pages, devoted to its fundamental data and inductions—was published more than a year ago. Mr. Spencer finds serious disadvantages in bringing out his system in these large volumes, which are both formidable to read and appear at such

wide intervals that their connections are apt to be forgotten. He will, therefore, in future, issue separately the successive divisions of these volumes as they are completed. The first division of Volume II. is on "The Development of Ceremonial Institutions," now published, and the next division will be on "The Development of Political Institutions," and upon this he is now engaged. It will be followed by the divisions on "The Development of Ecclesiastical and Industrial Institutions."

If we define government as the control of conduct in relation to others, then it is of two kinds—that by the coercion of the civil power, and that by the mandates of social custom and ceremonial observance. The regulation of conduct is divided between civil law and the unwritten codes of custom; and of these two authorities the latter has by far the largest share in regulating men's lives. In the genesis of social relations, ceremonial government arises earlier than political government, is more general, and far more potent in its social restraints and requirements. While yet primitive society is in a wholly unorganized condition, with no coercive rule, perhaps, but the will of the chief, the savage nature becomes spontaneously amenable to imperative observances in daily intercourse. And, in the highest state of civilization, social life is dominated by the same despotic agency. To understand the present constitution of society, therefore, and the forces by which it is regulated, it becomes necessary to treat the origin and growth of social observance as a part of sociological science, and this is the object of the volume on "Ceremonial Institutions."

Mr. Spencer's conclusions throughout rest upon a wide survey of the facts concerning primitive customs and manners, gathered from all sources, and are illustrated with a wealth of examples that gives great force and impressiveness to his conclusions. This very full and complete illustration of the subject has been objected to by some, on the ground that such a profusion of facts and examples is unnecessary to his exposition, and becomes wearisome to the reader; and the same criticism has been passed upon other parts of his philosophical works. To this he replies, in his preface, that, while not unconscious of the defect, it is still unavoidable, as scientific proof rather than artistic merit is the end he is aiming at. He says: "If sociological generalizations are to pass out of the stage of opinion into the stage of established truth, it can only be through extensive accumulations of instances; the inductions must be wide if the conclusions are to be accepted as valid. Especially while there continues the belief that social phenomena are not the subject-matter of a science, it is requisite that the correlations among them should be shown to hold in multitudinous cases. Evidence furnished by various races in various parts of the world must be given, before there can be rebutted the allegation that the inferences drawn are not true, or are but partially true. Indeed, of social phenomena more than all other phenomena, it must, because of their complexity, hold that only by comparisons of many examples can fundamental relations be distinguished from superficial relations."

Some of the chapters of the volume on "Ceremonial Institutions" have appeared in the pages of this Monthly, but several new and important topics are treated in the volume, which make it the completest as well as the most original discussion of the subject that has yet appeared. It is, besides, an extremely interesting book to read, as it gives much curious information regarding the origin and meaning of social usages that concern everybody, while at the same time there is no erudite or abstract philosophy in it to task the reader's effort.

THE THEORY OF POLITICAL ECONOMY. By W. STANLEY JEVONS, LL. D., M. A., F.R.S. London: Macmillan & Co. Second edition. Pp. 314. Price, $3.50.

THE above work presents, in the most complete form yet given it, Professor Jevons's mathematical theory of economics, first published by him in a volume nine years ago, though worked out and presented in its main features as far back as 1862. The idea that economics is essentially a mathematical science appears not to be new, but, during the ascendancy of other views, it has for the most part been neglected, and the work accomplished remained in obscurity.

Professor Jevons has been at some pains to investigate the bibliography of the subject, and finds it surprisingly full and of considerable value.

It appears from his researches that the theory, as stated by him, and in a form closely resembling his, by M. Léon Walras, of Lausanne, has been anticipated in its chief features by Gossen, of Germany, and Cournot, of France. This is somewhat remarkable, as these writers worked not only independently of each other, but with little or no knowledge of what had been done by any others. They had, in fact, to begin at the beginning and work out the entire subject for themselves. Professor Jevons regards this independent arrival at substantially the same views of the "fundamental ideas of economics," by four different inquirers, as strong evidence of their probable truth. He appends to the present edition of his work a fuller list than was possible in the first of all the writers whose names he has been able to discover, who treat the science on this side, that future students may not remain in ignorance of what has been accomplished.

The present unsatisfactory state of economics is regarded by him as due to the failure, on the part of economists, to distinguish between several branches of knowledge which, though closely allied, are yet separate. There should be a distinction drawn between the abstract science which has to do with the fundamental relations of economic quantities and those special concrete sciences which depend upon it. The relation of this abstract science to the concrete ones he holds to be somewhat analogous to that between the science of mechanics and the physical sciences, all of which have their basis more or less in it. Pleasure and pain are, according to him, the ultimate factors with which economics has to deal, and how to increase the one and decrease the other to the greatest extent possible is the problem to be solved, or, stated more specifically, the problem is: "Given a certain population, with various needs and powers of production, in possession of certain lands and other sources of material; required the mode of employing their labor which will maximize the utility of the produce." In order to subject the science to his analysis, Professor Jevons introduces into economic quantities the physical conception of dimension. These quantities can then be treated geometrically, and their various relations expressed by formulas. A feeling, such as a pleasure or a pain, he considers possessed of two dimensions, intensity and duration, the amount of which can be varied by varying either or both of the factors. A curve whose ordinates correspond with the intensity of the feeling and the abcissas with its duration will express the law of the variation of the intensity, when this variation is continuous.

The relations of the various economic quantities involved would, in any case, be known when the elements of such a curve were determined, or, as the mathematicians say, when the form of the function is known. The agreement of the calculated result, when numerical data are introduced into the formulas, with the actual result, would be the verification of the formulas. Such numerical data, consisting mainly in "accurate accounts of the quantities of goods possessed and consumed by the community, and the prices at which they are exchanged," are not now easily attainable, and formulas can not, therefore, be at present verified. As these data become available, however, Professor Jevons thinks that the science can gradually be raised to the position of an exact one.

A large portion of the present work is devoted to the elucidation of the problem of exchange value, which is necessarily fundamental in any economic exposition. Exchange value, or, as he terms it, "the ratio of exchange," is held by him to be directly dependent upon utility and only ultimately upon cost of production. In his theory of utility he draws a distinction between the total utility of any commodity and its degree of utility at any point of supply, the person concerned being the sole judge in any case considered of what is or is not useful. In illustration, the total utility of such a thing as food is infinitely great, as it is necessary to life; but, when we have abundance, the utility of an addition is very small and may be zero. Considering the increase of supply to be made by adding increments of commodity, the degree of utility of the last increment added, or of that to be add-

ed, he terms the final degree, and it is on this that the ratio of exchange depends. He finds the explanation of the fact that such a very useful commodity as water has little or no power in exchange in the circumstance that its final degree of utility is ordinarily very small. When water becomes scarce the higher degrees of utility are approached, and, if the scarcity is prolonged, it may acquire a high purchasing power. Geometrically, total utility would correspond with the area inclosed between a curve and its lines of reference, and the degree of utility at any point with the ordinate of the curve at that point. His conception of utility corresponds closely with that as expressed in ordinary language, the total utility being the entire usefulness of any commodity, the degree of utility the esteem or urgency of desire, and the ratio of exchange the purchasing power.

As viewed by Professor Jevons, the problem of exchange is properly a dynamic one. Commodities are being continuously manufactured, exchanged, and consumed. The solution of the problem, therefore, involves determining not only the conditions of equilibrium at which exchange would cease, but the rate at which it would go on before equilibrium was established. The statical problem—the obtaining of the conditions of equilibrium—is only attempted in the present work. He considers that the parties to the exchange are possessed of certain fixed quantities of commodity which they keep exchanging until the point is reached when they are satisfied, and have no further desire to part with or acquire any more. His analysis brings him to the conclusion that "the ratio of exchange of any two commodities will be the reciprocal of the ratio of the final degrees of utility of the quantities available for consumption after the exchange is completed."

The usual treatment of labor by economists Professor Jevons regards as singularly perverted. The science starts with labor, and how to use this labor to the greatest advantage is the very problem with which it deals. But economists generally do not proceed far before they turn about and consider labor as a commodity which capitalists buy up. "Labor becomes itself the object," he says, "of the laws of supply and demand, instead of those laws acting in the distribution of the products of labor." His conclusion is that "the wages of a workingman are ultimately coincident with what he produces, after the deduction of rent, taxes, interest, and the interest of capital." According to his analysis, when in any case of production the labor is distributed, the ratio of the final degrees of utility of the products equals the ratio of the productiveness of the labor concerned in each product. He thus arrives at the result that the ratio of exchange is ultimately determined by the cost of production, through the effect which this has in determining the final degrees of utility of the commodities. The conclusions of the work, on the subject of exchange, Professor Jevons sums up as follows: "Quantities of commodity exchanged vary directly as the quantities produced by the same labor, and inversely as their values, prices, costs of production, and final degrees of utility."

Professor Jevons accepts the current definition of capital, though he broadens it somewhat, and his analysis of the subject leads him to conclusions closely agreeing with those of Ricardo and the economists who have followed him.

The doctrine of rent he regards as having long been in a scientific form.

Of the value of the theory, both as to what is obtained and as to its possible development as a comprehensive treatment of economics, it is for economists to decide, but it can be studied with interest and profit by all who desire to know one of the directions in which present economic inquiry is tending. The book is written in the clear manner peculiar to all the work of this author, and can be readily perused by any one having the slightest knowledge of the calculus.

THE CHEMISTRY OF COMMON LIFE. By JAMES F. W. JOHNSTON. New edition, and brought down to the Present Time by A. H. CHURCH. New York: D. Appleton & Co. 1880. 1 vol., pp. 592. Price, $2.

A REVISED edition of this favorite work, first issued twenty-five years ago, will be welcomed everywhere. It has ever been the model of a popular scientific work, and has had many imitations—notably, Lewes's

"Physiology of Common Life"—but none of them have approached the perfection of the original. Johnston was led to prepare it by his pioneer studies in agricultural chemistry, which not only familiarized him with all common subjects, but, what was of far more importance, gave him a sympathetic interest in the common people. No mere passionate experimenter or laboratory devotee could ever have produced such a work. Great changes have come over the field of chemical science during the last quarter of a century, but they have affected this work much less than more theoretical treatises, as facts change less than their interpretations. Nevertheless, the book had fallen behind the age, and needed to be brought up to date. The entire work has been carefully revised by Professor Church, somewhat enlarged, and brought down to the latest date. Some new matter, aside from that necessary to embody the latest knowledge, has been added by the editor, the most important of which is the article upon "The Colors we admire." The book is written for the people, in a clear and popular manner, without technicalities, and seeks to answer questions that commonly arise in every-day life about every-day things. It treats such things as the air we breathe and the water we drink in their relations to human life and health; the soil that we cultivate and the plants raised; the food we eat and beverages we drink; the odors that are agreeable and disagreeable, and the reasons why they are so; the colors that stand in like relation to us; the physiological processes of the body, and the condition of health. It answers, in fact, a thousand and one questions which all ought to know, but which they do not, and will be found a valuable addition to the library of every household.

ASTRONOMY. For Schools and Colleges. By SIMON NEWCOMB, LL. D., Superintendent of "American Ephemeris and Nautical Almanac," and EDWARD S. HOLDEN, M. A., Professor in the United States Naval Observatory. New York: Henry Holt & Co. Pp. 512. Price, $2.50.

THE presumptions in favor of this work, which are created by the names of its authors, are abundantly justified by its critical examination. It may be commended as in every respect a first-class astronomical textbook for college students. The authors say in their preface that "the work is designed principally for the use of those who desire to pursue the study of astronomy as a branch of liberal education." Yet its plan is such that it may subserve the uses of different grades of students, and those having in view quite different objects. The subject-matter is divided into two classes, distinguished by the size of the type. The portions in large type form a complete course for the use of those who desire only such a general knowledge of the subject as can be acquired without the application of advanced mathematics. This is the part that will interest the general reader. The portions in small type comprise additions for the use of those students who either desire a more detailed and precise knowledge of the subject, or who intend to make astronomy a special study. The work is copiously illustrated, is written with great clearness, and its explanations are admirable.

PROGRESS AND POVERTY. An Inquiry into the Cause of Industrial Depressions, and of Increase of Want with Increasing Wealth; the Remedy. By HENRY GEORGE. One Volume. New York: D. Appleton & Co. 1880. Pp. 512. Price, $2.

IN the previous pages of this Monthly the reader will find an article on the "Study of Political Economy" that will be pretty certain to interest him. He will see that this so-called "dismal science" is capable of being presented in an attractive way. But after looking it over with satisfaction, as he will be sure to do, he may still say: "This man puts the subject very pleasantly in a lecture, but where are the treatises which can realize for us the interest of treatment here promised? All the books I have yet found on this topic are very prosy affairs."

Well, the author of this essay has himself made a book on political economy, so that he can be tried by his own test. He has made a pretty big book too (although it is not expensive), and, whatever may be its faults, dryness and dullness are not among them. It is full of vital thought, and is written with earnestness and power. We might say it is the most engaging book

on economical subjects that we have ever read, but some may think that is not saying much, after all; and so we will add that it is a work hard to lay down when once begun.

The author is a man of marked intellectual power, of independent convictions, and of strong human sympathies. He lives in San Francisco, where he has been for thirty years, watching the growth of society in a forming State. He has observed the working of the forces by which a modern community has grown up from a rough and formless to a settled, organized, and advanced condition.

The outcome of all this immediate observation and of the extensive study of the conditions of other communities is the conviction that the imminent problem of the age is the intimate association of progress and poverty. The persistence of poverty amid rapidly advancing wealth is a widely recognized and deplorable fact, which has impressed itself more and more strongly upon thoughtful people. This century has been characterized by an enormous increase of productive power and an immense multiplication of riches. But this increasing wealth has neither been equalized throughout the population, nor has there been any tendency to equalization. The gulf between rich and poor has been widening, and neither the rapid strides of invention nor the enormous development of the labor-saving and the wealth-creating arts has been able to arrest this widening.

Mr. George says: "The association of poverty with progress is the great enigma of our times. It is the central fact from which spring industrial, social, and political difficulties that perplex the world, and with which statesmanship and philanthropy and education grapple in vain. From it come the clouds that overhang the future of the most progressive and self-reliant nations. It is the riddle which the Sphinx of Fate puts to our civilization, and which not to answer is to be destroyed. So long as all the increased wealth which modern progress brings goes but to build up great fortunes, to increase luxury, and make sharper the contrast between the House of Have and the House of Want, progress is not real and can not be permanent. The reaction must come."

Again he says: "I propose in the following pages to attempt to solve by the methods of political economy the great problem I have outlined. I propose to seek the law which associates poverty with progress, and increasing want with advancing wealth; and I believe that in the explanation of this paradox we shall find the explanation of those recurring seasons of industrial and commercial paralysis which, viewed independently of their relations to more general phenomena, seem so inexplicable. Properly commenced and carefully pursued, such an investigation must yield a conclusion that will stand every test, and, as truth, will correlate with all other truth. For in the sequence of phenomena there is no accident. Every effect has a cause, and every fact implies a preceding fact."

Now, in a brief notice like this we can neither give, nor attempt to give, Mr. George's solution of his problem. But we may say he finds it in the land question, and its remedy in a very radical and thorough reforming of our land policy. We do not here endorse Mr. George's work, but we very strongly recommend it to those who take interest in the living questions of the time. We hope soon to give a sketch of his argument, but no outline can do it justice. We may add that, aside from his special discussion, the book abounds in information on economical principles and facts admirably put, and which will well repay perusal.

LECTURES AND ESSAYS. By the late WILLIAM KINGDON CLIFFORD, F. R. S. Edited by Leslie Stephen and Frederick Pollock. With an Introduction by F. Pollock. In Two Volumes. With Two Portraits. New York: Macmillan & Co. Pp. 661. Price, $7.50.

CLIFFORD has been so thoroughly sifted, and his position as a thinker is so well known, that little needs here to be said upon this point in introducing his essays to the reader's attention. But the massing together of his intellectual work will heighten his fame. For only when his brilliant and powerful disquisitions are brought together, so that we can compare them and discern their variety and scope, is it possible to do justice to his genius. That he was a transcendent mathematician most readers can only recognize by what others say, but the

essays can be judged by all who are capable of thinking. The feature that strikes us most in reperusing these volumes, and to which we have before called attention as a characteristic of his writings, is the mastery they display of the art of luminous exposition in dealing with obscure and abstruse subjects. Here Clifford is quite incomparable, and there are parts of these volumes which will long survive as models of popular statement, delightful to the reader from their vividness and marvelous lucidity. Clifford is at his best in disentangling and laying out to view subjects which baffle ordinary grasp and penetration. He may be said to make perfectly clear things which ordinary people complain that they can only partially and imperfectly understand. To take a random example, we open volume one, and happen to strike, in the middle of it, a discourse upon atoms. This might be at once taken as a crucial test of Clifford's power of picturing by language. Everybody knows something about atoms, and everybody is bewildered in the attempt to form such a conception of them as will explain the mutual influences and interactions of the material bodies which are composed of atoms. Turning to the beginning of this lecture, which was a popular effort in a Sunday course, we find him thus opening his subject.

If I were to wet my finger and then rub it along the edge of this glass I should no doubt persuade the glass to give out a certain musical note. So, also, if I were to sing to that glass the same note loud enough, I should get the glass to answer me back with a note.

I want you to remember that fact, because it is of capital importance for the arguments we shall have to consider to-night. The very same note which I can get the tumbler to give out by agitating it, by rubbing the edge, that same note I can also get the tumbler to answer back to me when I sing to it. Now, remembering that, please to conceive a rather complicated thing that I am now going to describe to you. The same property that belongs to the glass belongs also to a bell which is made out of metal. If that bell is agitated by being struck, or in any other way, it will give out the same sound that it will answer back, if you sing that sound to it; but if you sing a different sound to it then it will not answer.

Now, suppose that I have several of these metal bells which answer to quite different notes, and that they are all fastened to a set of elastic stalks which spring out of a certain center to which they are fastened. All these bells, then, are not only fastened to these stalks, but they are held there in such a way that they can spin round upon the points to which they are fastened.

And then the center to which these elastic stalks are fastened or suspended you may imagine as able to move in all manners of directions, and that the whole structure made up of these bells and stalks and center is able to spin round any axis whatever. We must also suppose that there is surrounding this structure a certain framework. We will suppose the framework to be made of some elastic material, so that it is able to be pressed in to a certain extent. Suppose that framework is made of whalebone, if you like. This structure I am going for the present to call an "atom." I do not mean to say that atoms are made of a structure like that. I do not mean to say that there is anything in an atom which is in the shape of a bell; and I do not mean to say that there is anything analogous to an elastic stalk in it. But what I mean is this—that an atom is something that is capable of vibrating at certain definite rates; also that it is capable of other motions of its parts besides those vibrations at certain definite rates; and also that it is capable of spinning round about any axis. Now, by the framework which I suppose to be put round that structure, made out of bells and elastic stalks, I mean this—that supposing you had two such structures, then you can not put them closer together than a certain distance, but they will begin to resist being put close together, after you have put them as near as that, and they will push each other away if you attempt to put them closer. That is all I mean, then. You must only suppose that that structure is described, and that set of ideas is put together just for the sake of giving us some definite notion of a thing which has similar properties to that structure. But you must not suppose that there is any special part of an atom which has got a bell-like form, or any part like an elastic stalk made out of whalebone.

A large part of these essays is devoted to the discussion of the moral and religious problems which so prominently occupy the speculative attention of the age. These subjects are all handled with the author's customary originality and felicity; but it is impossible here to give any account of them. He attempted no system, and his work must be looked upon as consisting of elaborate fragments, valuable for what they are separately worth. We quote a portion of the criticism passed upon him by the London "Spectator":

The late Professor Clifford was a meteoric sort of moral phenomenon, who to many, even of those who had some personal knowledge of his extraordinary powers, was more of a bewilderment than a light. He was a man of rare wit and rare powers of fascination, of extraordinary courage and extraordinary agility, both

physical and mental, very great kindliness and very great audacity, enthusiastic disinterestedness and almost measureless irreverence. He was a great master of gymnastic, who, when he came out second wrangler at Cambridge, was much prouder of being mentioned in "Bell's Life" as a great athlete than of being second wrangler. "His nerve at dangerous heights," wrote a friend who was his rival in gymnastic feats, "was extraordinary. I am appalled now to think that he climbed up and sat on the cross-bars of the weather-cock on a church-tower; and, when, by way of doing something worse, I went up and hung by my toes to the bars, he did the same." During a journey in France, when the boat had left the quay at Havre, Clifford, arriving late, jumped on board of it, "with one of those apparently unpremeditated springs which look so well in the gymnasium." His flexibility and complete command of his own powers, both of mind and body, were probably as great as any human being ever possessed. And as he seems to have been entirely free from anything like giddiness in his gymnastic feats, so he seems to have been equally free from anything like awe in the equally marvelous gymnastic feats of his mind, treating the infinity and eternity in which his fellow creatures believed with the same sort of contemptuous familiarity with which he treated the ecclesiastical height he had once reached, only to balance himself by his toes on the weather-vane. He speaks, indeed, in the least irreverent of his antitheistic papers, of having parted from his faith in God "with such searching trouble as only cradle faiths can cause." And no doubt he must have felt something which entitled him to use this language, for Clifford was sincerity itself. Nevertheless, this is almost the only passage we have met with which points to his having gone through any crisis of the kind, while there are a great many in which he treats the faith in God with such utter, such cold contempt, that it is not easy to understand how he could ever have regarded it as being the light of his light and the life of his life, and much less how he could have realized that other men were still so regarding it, while he was launching his satire at them. In such a passage as the following, for example, he seems to be trying to show that he was as reckless of the awe which the faith in God and eternal life generate, as when, hanging with his toes on the church-vane, he was reckless of the fears which such a position as his would impart to most men: "For, after all, such a helper of man outside of humanity, the truth will not allow us to see. The dim and shadowy outlines of the superhuman deity fade slowly away from before us; and, as the mist of his presence floats aside, we perceive with greater and greater clearness the shape of a yet grander and nobler figure—of Him who made all gods, and shall unmake them. From the dim dawn of history, and from the inmost depth of every soul, the face of our father Man looks out upon us with the fire of eternal youth in his eyes, and says, 'Before Jehovah was, I am.'" We transcribe the words of this parody with reluctance, and something almost of shame, but still with the feeling that they are essential to the understanding of the erratic man who wrote them, and who never could have written them if he had not been strangely deficient in those many fine chords of sympathy with his fellow men which in other skeptics like himself remain vibrating, and securing for them a certain community of sentiment with their fellows, long after the sympathy of conviction, necessary originally to agitate them to their full extent, has vanished. Doubtless, Clifford held all moral conventionality in utter horror. As he once told an audience, in face of the great danger which threatens nations that they may crystallize, like the Chinese, into inflexible habits of thought and feeling which would shut them out from progress, "it is not right to be proper." But still such a parody as we have quoted on what is to so many men the most sacred of human utterances, one indeed embodying the most solemn passion of conviction through which the heart of man has ever passed, would not have been, in most men's mouths, so much a violation of propriety as a deliberate insult to the heart of multitudes. That Professor Clifford did not so regard it seems to us quite evident. But that only shows how curiously destitute he was of some of those chords of sympathetic feeling, without the help of which it is impossible to judge with any adequacy the moral world in which you live. And with all his wonderful talent for society, and that extreme kindliness of his nature which so fascinated children, Professor Clifford certainly showed signs of a curious nakedness of the finer moral sympathies, a nakedness diminishing in great degree both the impression of cruelty which the mordant and contemptuous character of his attacks on religion would otherwise make upon us, and also, in some degree at least, the intellectual weight to be attached to his undoubted genius when it worked upon subjects of this kind.

AN ESSAY ON THE BIBLE NARRATIVE OF CREATION: GENESIS I.–II. By Professor A. R. GROTE. New York: Asa K. Butts.

WHAT to do with the first chapters of Genesis has long been a perplexity with those who hold it to be a veritable account of the origin of the universe, and who at the same time accept the conclusions of modern science on that subject. Differences are confessed and great ingenuity has been expended in reconciling them. In a thin volume of eighty-two pages Professor Grote gives us the results of his study of the question. He gives two versions side by side, the Hebrew text in English letters, together with the translation. Then follows a chapter on "Literary Criticism." In this the writer follows the researches

of Ewald and Kuenen with regard to the name of the Deity. He makes use in his translation of the terms "Elohim" and "Yahveh Elohim," because the words "God" and "Lord God" do not translate the Hebrew correctly, the plural form of Elohim being lost in the English word "God," which is a substitute for and not a translation of the Hebrew term Elohim. Another important deviation of Professor Grote's translation from the King James version lies in the fact that the word *ha-Adam* is constantly translated "the man" throughout, whereas the authorized version from Genesis ii. 19 to the end of the creational history of the first man uses the proper name "Adam," the Hebrew remaining the same as before. The author shows that the two chapters can not be considered as a continuous narrative, the first account ending at chapter ii. 3, and the second commencing chapter ii. 4. The descrepancies between the two accounts are very fully indicated, and the different points of view from which they were written explained.

The author then gives a chapter on the "Testimony of Archæology," describing the Assyrian tablets of the Genesis, and he lays special stress on the occurrence of the deity *Il* in the Chaldean Pantheon, and shows its equivalence to the Hebrew *El-Eloah*, with its plural Elohim, and of the Arabic *Allah*. The author concludes that the legends of the creation having existed for a long time as oral traditions, were committed to writing before the union of the kingdoms, or before 2234 B. C., when Abraham, according to Biblical chronology, was not yet born. The date of Moses is about 1245 B. C., that of Menephthah, the Pharaoh of the Exodus. The Chaldean account is thus about a thousand years older than the composition of the Biblical legends. Interesting chapters follow on the myths of the old world which resemble those of Genesis.

The author then proceeds to the "testimony of facts." Here the descrepancies between the two accounts in Genesis and the discoveries of science are clearly pointed out. In his "Conclusion" and "Philosophy," the last two chapters of the book, the author contends that the literal teaching of the book of Genesis is hurtful to the minds of children, and an impediment to the general progress of mankind. Unessential as much of the scientific criticism, directed against the ethical portions of Scripture, is seen to be, such criticism must be appropriate when directed against a portion which deals almost exclusively with statements of facts. A classification of the treatment of religion by the Indo-European and Semitic races is attempted by the author, in which he shows that the leaning of the Indo-European religions is toward the intellectual side of the mind in its treatment of external objects. On the other hand, the leaning of the Semitic religions is toward the emotional side in its treatment of human conduct and family relations. The Gods of the two accounts in Genesis, expressed by nouns plural in form, mark a reminiscence of a preceding plurality of deities, and are plainly not consistent with monotheism. There has been, on the one hand, a growth in the direction of a recognition of a universal God, who at one time was tribal and national; and, on the other hand, there has been a progress in the direction of a recognition of one God, the final cause of nature, who has absorbed the minor deities into himself.

With regard to the two accounts in Genesis, the author concludes that we have to do with an original myth which had undergone many changes before it was cast into the two shapes in which we find it in the Hebrew Bible. Since that time, and when the latter could no longer change, many differing conceptions of the origin of things have found their orthodoxy in a play upon the meaning of the words and a distortion of their true intent. A lax wording, a shorter and more general statement, a monotheistic conception, give an elasticity to the story of Genesis, and a certain adaptiveness to later discoveries; but, in its treatment of the heavens and heavenly bodies in the little bit of the earth on which its miracles are performed, it is still akin to the notions of the Homeric ages with regard to the universe.

The book is characterized by directness of argument, and the best material has been diligently used. There can be no reasonable objection to its temper and tone, and, we think, its thorough fairness. Written with the object of giving a good foundation to those who have been led to reject the inspiration of Genesis, there is nothing in it

which ought to be offensive to those who still accept that inspiration; rather is there abundant material for a careful resurvey of their position in the face of the new facts. The archæologist and philologist will find many new points in the book, which is noteworthy for its additions to science as well as for its distinctive literary merits.

THE PHYSICAL HISTORY OF THE TRIASSIC FORMATION OF NEW JERSEY AND THE CONNECTICUT VALLEY. By ISRAEL C. RUSSELL. 1878.

THE Triassic of New Jersey and of the Connecticut Valley are supposed by the author to be parts of one formation, which was continuous over the intervening area. The deposit, he thinks, could not have been less than 25,000 feet thick, all or nearly all of which has been removed by denudation, excepting the beds which remain in the Connecticut Valley and New Jersey. Professor Dana, commenting on this subject in the April number of the "American Journal of Science and Arts," says, "That a thickness of 25,000 feet of water made sandstone over an area of metamorphic rock a hundred miles wide, as in the present instance, implies a subsidence of the region of 25,000 feet during its formation." There must also have been an elevation of not only 25,000 feet, but enough more to give a pitch of the slopes of about 15° as now shown. This would put the western side of the Connecticut Valley 20,000 feet above the eastern side, and the site of New York City some 15,000 to 20,000 feet above its present level, with 25,000 feet of sandstone over it.

ERASMUS DARWIN. By ERNST KRAUSE. Translated from the German by W. S. Dallas, with a Preliminary Notice by Charles Darwin. Portrait and Woodcuts. Pp. 216. Price, $1.25.

THIS interesting little volume will be welcomed by many readers, as it gives a fresh and compendious account of a man of genius whose name was celebrated in the last century, and is now brought into new prominence by the world-wide eminence of his grandson. Dr. Erasmus Darwin, who was born in 1731, and died in 1802, made a considerable impression upon his age as a poet and naturalist. He took a view of organic nature very similar to that developed in our own time by Mr. Charles Darwin, although his speculations were crude from the imperfection of knowledge, and were, of course, regarded as in the last degree wild and baseless. His poetry, although in some respects meritorious, was not of the highest order, and was but little read after he had passed away; and, as his biological doctrines were regarded as futile and worthless, there was little to keep his memory alive in the present century. But attention to what he did in science has been recently revived, and the more critical study of his works now shows that his claims and character have been greatly depreciated. The present volume has first done justice to his fame.

Mr. Charles Darwin, in his "Origin of Species," made a short note concerning his grandfather's biological opinions, and this struck the attention of Dr. Krause, a German *savant*, who entered upon a careful study of the writings of the elder Darwin, and published a biographical and critical essay upon the subject in the "Kosmos." In this essay Dr. Krause says: "This man, equally eminent as philanthropist, physician, naturalist, philosopher, and poet, is far less known and valued by posterity than he deserves, in comparison with other persons who occupy a similar rank. It is true that what is perhaps the most important of his many-sided endowments, namely, his broad views of the philosophy of nature, was not intelligible to his contemporaries; it is only now, after the lapse of a hundred years, that by the labors of one of his descendants we are in a position to estimate at its true value the wonderful perceptivity, amounting almost to divination, that he displayed in the domain of biology. For in him we find the same indefatigable spirit of research, and almost the same biological tendency, as in his grandson; and we might, not without justice, assert that the latter has succeeded to an intellectual inheritance, and carried out a programme, sketched forth and left behind by his grandfather."

Mr. Charles Darwin procured a translation of Dr. Krause's article, and, being in possession of much information that he had gathered in relation to his eminent ancestor, he has written a preliminary sketch which occupies 127 pages of the volume before us.

It gives an excellent account of its subject, supplementing Dr. Krause's paper, so that the readers of the book will be able to form not only a proper estimate of the man, but the condition of science in his time. A life of Erasmus Darwin, published in 1804, was written by a Miss Seward, but it seems to have contained certain gross misrepresentations of his character, which it is one of the objects of the present sketch to dispel. The authoress of the biography was long an inmate of Dr. Darwin's family, and when his first wife died would have been glad to take her place. But the Doctor chose another lady, and Miss Seward paid them both off in her biographical book. She subsequently retracted her objectionable statements, but the erroneous impressions, created by her book, were widely disseminated.

Mr. Darwin writes unreservedly but judicially of his grandfather's traits, and remarks that perhaps there is no safer test of a man's real character than that of his long-continued friendship with good and able men. Darwin's intimate and almost life-long friends were such men as Josiah Wedgwood, Keir the chemist, Day, the author of "Sandford and Merton," Bolton and Watt the engineers, and Mr. Edgeworth. A fine likeness of Dr. Darwin accompanies the volume, together with engravings of his birthplace, Elston Hall, and the Breadsall Priory, near Derby, where he lived for many years, and in which he died.

EIGHTH, NINTH, AND TENTH ANNUAL REPORTS OF THE GEOLOGICAL SURVEY OF INDIANA, for the Years 1876, 1877, 1878. By E. T. COX, State Geologist, assisted by Professor JOHN COLLETT and Dr. G. M. LEVETTE. Indianapolis, 1879.

THESE reports make a volume of 541 pages, and are illustrated by numerous diagrams and maps. The detailed reports are of three counties—Wayne, Crawford, and Harrison. These, as well as special reports on clays, cements, building-stone, etc., are well written, and show thorough work. A general review of the geology of the State by Professor COX presents his conclusions on several points of interest. Of the glacial epoch, he says: "I see no evidence of a subsidence of land to terminate the glacial period, which continued until brought to a close by its own erosive force, aided by atmospheric and meteorological influences. . . . Its force was expended in eroding, cutting down, and removing mineral matter from a higher to a lower level." He does not believe it is possible for glaciers to make erosions to so great depths "as the beds of some of the great Northern lakes." The volume contains an excellent paper on archæology, a table of altitudes, catalogues of fossils and of recent flora, and, what is of especial value, "A Catalogue and Check-list of the Trees and Woody Shrubs of America north of Mexico." This was prepared by John W. Byrkit, Esq., of Indianapolis. The volume has a very full index.

MODERN METEOROLOGY. A Series of Six Lectures delivered under the Auspices of the London Meteorological Society in 1878. Illustrated. New York: D. Van Nostrand. 1879. Price, $1.50.

THESE lectures make a volume of 186 pages, and are a useful contribution to the science of meteorology. The subjects are treated in a somewhat elementary manner, but in the light of the latest researches. The first, and perhaps the most important lecture of the series, is by Robert James Mann, M. D., F. R. C. S., etc., on "The Physical Properties of the Atmosphere," and is a model of lucid scientific statement. Others are on "Air Temperature, its Distribution and Range"; "The Barometer and its Uses, Wind and Storms"; "Clouds and Weather Signs"; "Rain, Snow, Hail, and Atmospheric Electricity"; and "The Nature, Methods, and General Objects of Meteorology." This last, by Robert H. Scott, F. R. S., Secretary to the Meteorological Council, is worth careful perusal by both scientists and the general reader.

THE GREAT FUR LAND, OR SKETCHES OF LIFE IN THE HUDSON'S BAY TERRITORY. By H. M. ROBINSON. With numerous Illustrations. New York: G. P. Putnam's Sons. 1879. Price, $1.75.

THE fact that much of the contents of this volume first appeared in "Appletons' Journal" and "Harper's" and other magazines, does not detract from its value. It is a picturesque and thoroughly readable account of life and scenery in the region occupied by the Hudson's Bay Company, and

some of the pictures are uncommonly well drawn. The descriptions of the great fall hunt, of the manners and habits of the hunters, of traveling over the vast prairies during winter, of the mirage and other atmospheric phenomena, are excellent, and, although there is no attempt at scientific statement, they give one a good idea of the extent of an important industry, and of the kind of life adopted by those who pursue it.

THE BEREA SANDSTONE OF OHIO. By Professor EDWARD ORTON, of the Ohio State University. Pp. 9.

THIS is a review of the facts brought out by the Geological Survey of Ohio, concerning one of the most important geological formations of the State, the Berea sandstone. It extends in a continuous line of outcrop more than four hundred miles, through twenty-one counties, the stone of best quality, however, being found at Berea, in Cuyahoga County, whence its name. Building-stones and grindstones, to the amount of several million dollars, are annually obtained from this enormous deposit. The facts presented by Professor Orton are not only interesting from an economic point of view, but are of special value to the geologist.

PUBLICATIONS RECEIVED.

Report on Magnetic Determinations in Missouri. By Francis E. Nipher. Pp. 24, with Map.

Report of the Commissioners of Fisheries of California for 1878 and 1879. Pp. 61.

Indian Corn. By E Lewis Sturtevant, M. D., South Framingham, Massachusetts. 1880. Pp. 31.

"The American Entomologist." Edited by Charles V. Riley and A. S. Fuller. Monthly. Vol. I. New Series. No. 1. January, 1880. New York: Max Jaegerhuber, Publisher, 223 Pearl Street. Pp. 24. $2 per annum.

Responsibility restricted by Insane Delusion. By T. L. Wright. Bellefontaine, Ohio. Pp. 16.

How to learn Short-Hand. Baker. New York: S. R. Wells & Co. 1880. Pp. 43.

Notes of Students' Work in the Chemical Laboratory of the University of Virginia. No. VIII. Communicated by J. W. Mallet. London, 1879. Pp. 14.

Relations of Railroads to the Public. By F. B. Thurber, of New York City. Pp. 18.

The Origin of Force. By Stephen C. Hutchins. Albany. 1879. Pp. 8.

Some Additional Notes on Ozone. Pp. 22. Contributions from the Laboratory of the Stevens Institute of Technology. By Albert R. Leeds, Ph. D. Pp. 13. Reprints from "Journal of American Chemical Society."

Solar Parallax from the Velocity of Light. By D. P. Todd, M. A. Pp. 6.

Thirty-fourth Annual Report of the Director of the Astronomical Observatory of Harvard College. By Edward C. Pickering. Cambridge. 1880. Pp. 14.

A Lecture on Man. By Charles S. Bryant, A. M. St. Paul, Minnesota. Pp. 53. 35 cents.

"The American Monthly Microscopical Journal." Edited and Published by Romyn Hitchcock. Vol. I., No. 1. January, 1880. Pp. 20. 51 Maiden Lane, New York. $1 a year; single numbers, 15 cents.

Civilization: Is its Course natural or supernatural? Philadelphia: Charles H. Marot. 1879. Pp. 140.

Fourth Annual Report of the Board of Managers of the Wisconsin Industrial School for Girls. Milwaukee, 1880. Pp. 52.

Remedy for Existing Evils, Social and Political. By Judge S. D. J. Moore. Nashville. 1879. Pp. 116.

Notes on New England Isopoda. By Oscar Harger. Pp. 9.

New Characters of Mosasauroid Reptiles. By Professor O. C. Marsh. Pp. 5, with Plate.

On a New Theory of the Retaining Wall. By A. J. Du Bois, Ph. D. Reprint from "Journal of the Franklin Institute." Pp. 27.

The State of Prisons and of Child-saving Institutions in the Civilized World. By E. C. Wines, D. D., LL. D. Cambridge, 1880. Pp. 708.

Etymological Dictionary of the English Language. By Rev. Walter W. Skeat. Part II., Dor–Lit. $2.50 per part.

The Native Flowers and Ferns of the United States. By Thomas Meehan. Second Series. Parts 9, 10, 11, 12, Vol. I.; Parts 13, 14, 15, and 16, Vol. II. Illustrated.

On the Determination of Verdet's Constant in Absolute Units, and on the Specific Inductive Capacities of Certain Dielectrics. By J. E. H. Gordon, B. A. Cantab.

Brain-Work and Overwork. By Dr. H. C. Wood. Philadelphia: Presley W. Blakiston. 1880. Pp. 126. 50 cents.

Linkages for Different Forms and Uses of Articulated Links, by J. D. C. DeRoos; Theory of Solid and Braced Elastic Arches, by William Cain, C. E.; On the Motion of a Solid in a Fluid, by Thomas Craig, Ph.D. New York: Van Nostrand's Science Series. 1879. 50 cents each.

The Child's Catechism of Common Things. By John D. Champlin, Jr. New York: Henry Holt & Co. 1879. Pp. 289. 60 cents.

Outlines of the Art of Expression. By J. H. Gilmore, A. M. Boston: Ginn Bros. 1878. Pp. 117.

Blowpipe Analysis. By J. Landauer. London: Macmillan & Co. 1879. Pp. 161. $1.50.

Part V., Report of United States Commission of Fish and Fisheries for 1877. Propagation of Food Fishes. Washington: 1879. Pp. 981.

Problems of Life and Mind. By George H. Lewes. Third Series. Boston: Houghton, Osgood & Co. 1880. Pp. 500. $3.

The Economics of Industry. By Alfred Marshall and Mary Paley Marshall. London: Macmillan & Co. 1879. Pp. 231. $1.

Studies on Fermentation. By L. Pasteur. London: Macmillan & Co. 1879. Pp. 418. $6.50.

Popular Romances of the Middle Ages. By Sir George W. Cox and Eustace Hinton Jones. New York: Henry Holt & Co. 1880. Pp. 514. $2.25.

Pharmacographia: a History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India. By Friedrich A.

Flückiger and Daniel Hanbury, F. R. S. London: Macmillan & Co. 1879. Pp. 803. $5.

A Handbook of Double Stars. By Edward Crossley, Joseph Gledhill, and James M. Wilson. London: Macmillan & Co. 1879. Pp. 464. $6.

The Microscope in Medicine. By Lionel S. Beale. Philadelphia: Lindsay & Blakiston. 1878. Pp. 598. $7.50.

A Treatise on Vocal Physiology and Hygiene. By Gordon Holmes, F. R. C. P. Philadelphia: Presley W. Blakiston. 1880. Pp. 266. $2.

The Refutation of Darwinism and the Converse Theory of Development. By T. Warren O'Neill. Philadelphia: Lippincott & Co. 1880. Pp. 544. $2.50.

Sunshine and Storm in the East. By Mrs. Brassey. With upward of a Hundred Illustrations. New York: Henry Holt & Co. 1880. Pp. 448. $3.50.

England: her People, Polity, and Pursuits. By T. H. Escott. New York: Henry Holt & Co. 1880. Pp. 625. $4.

The Metaphysics of the School. By Thomas Harper. London: Macmillan & Co. 1879. Vol. I., pp. 592. $5.

A Manual of the Antiquity of Man. By J. D. Maclean. Cincinnati: Robert Clark & Co. 1879. Pp. 159. $1.

How to educate the Feelings or Affections. By Charles Bray. Edited by Nelson Sizer. New York: S. R. Wells & Co. 1880. $1.50.

POPULAR MISCELLANY.

Action of Organic Acids on Minerals.—At a recent meeting of the New York Academy of Sciences, Professor H. Carrington Bolton, of Trinity College, Hartford, communicated the results of a continuation of his researches on the behavior of minerals with organic acids. In a previous paper (read in 1877) he gave the reactions of ninety-five minerals with citric acid; in the present paper he extended the investigation to two hundred species. Dr. Bolton stated that citric acid has a power of decomposing all classes of minerals little less than that possessed by hydrochloric acid, and that this very difference in degree gives the organic acid an advantage over the mineral acid in the determination of species. Besides treating the minerals with a saturated solution of citric acid, he examined the action of the same solution, to which solid sodium nitrate is added. This mixture proves to be a very powerful solvent, dissolving bismuth, antimony, arsenic, copper, lead, tin, mercury, and silver, and nearly all the natural sulphides. The addition of solid potassium iodide to the solution of citric acid also greatly increases its decomposing power. Applying these reagents to minerals, Dr. Bolton obtained the following results: 1. Complete solution of carbonates, with liberation of carbonic-acid gas. 2. More or less complete decomposition of oxides, phosphates, etc. 3. More or less complete decomposition of sulphides, with liberation of sulphuretted hydrogen. 4. Decomposition of sulphides, with oxidation of the sulphur. 5. Decomposition of silicates, with separation of slimy or gelatinous silica. 6. Decomposition of certain species, with formation of characteristic precipitates. 7. Wholly negative action. The exact behavior of each of the two hundred minerals was given in a printed table, copies of which the speaker distributed to the audience. The application of this investigation is twofold: 1. The utility of the methods in field-work, owing to the portability of the reagents in a dry state; and, 2. The relation of these reactions to the geological work of the organic acids of the soil. The latter point is of much importance, and merits further researches.

How Snakes shed their Skins.—Under the title "About Snakes" in this department of our last number, we gave Dr. H. F. Hutchinson's mode of accounting for the way snakes get out of their old skins. Professor Samuel Lockwood, of Freehold, New Jersey, has witnessed the process, and, from a description of it given in his own inimitable style in a late number of "Nature," we gather the following interesting facts, which, as will be seen, do not support the hypothesis of Dr. Hutchinson: A female snake had already begun to cast her skin when Professor Lockwood made his first observation, but the process was going on very slowly. The skin was slightly torn at the snout, and the head and a little of the neck were denuded. As it separated from the neck it had a sort of "back-creeping aspect"; there was no rubbing against exterior objects, and indeed it looked as if the change going on might be the work of an invisible power. Closer observation showed that there was a systematic alternate swelling of the body at the neck of the skin, thus stretching it, and making a shoulder in front of this neck, each swelling pushing the loosened skin a little backward. As soon as the process reached the larger ribs it went on more rapidly, and in the following way:

"Exactly at the place where the skin seems to be moving backward, a pair of ribs expands. This action enlarges or puffs out the body, and by stretching loosens the skin at that place. In this movement both ribs in the pair act at the same time, just as the two blades of the scissors open together. Now comes a second movement of this pair of ribs, in which action the two ribs alternate with each other. One of them—say the one on the right side—is pushed forward and made to slip out of and in front of the constriction made by the swelling, when it immediately works backward, that is, against the neck of the double receding skin. Now the left rib makes a like advance, and in a similar manner presses backward." Thus, for every backward movement of the inverting skin, there are three rhythmic movements: First, the expansion of one pair of ribs; second, the swelling of the body at that spot; and, third, the pushing back of the skin by the alternate action of each rib. "The cast-off skin is presented inside out, so that every scale is now seen on its under or concave side, and this is also true of the eye-scales. To all this there is one exception; the last scale of the tail is a hollow pyramidal or four-sided spike. . . . When the shedding has reached this scale a sharp shake of the extremity is sufficient, and the uneverted spike is left inside of its everted skin." The entire process witnessed by Professor Lockwood took only half an hour, but he says that if a snake is in poor health the casting of its old clothes takes longer and is a much more difficult matter.

A New Food-Fish.—Among the many remarkable results given in the last report of the United States Fish Commission is the discovery of a very important food-fish, entirely unknown to our fishermen. It is a large flounder, the *Glyptocephalus cynoglossus*, and is known in Europe as the pole or craig. But in Europe it is far from being plentiful, and is highly esteemed as having some of the best qualities of the turbot, especially the presence of that delicious gelatinous fat along the fins. Much of the work of the Commission has consisted of dredging in water of various depths. While trawling with a beam at distances from five to ten miles from the shore, the fish was discovered, and in great quantities; so great, indeed, that a fifteen to twenty minutes' drag would sometimes furnish as many as five hundred pounds of the fish. The reason that this fish has not been known hitherto is due to the fact that the beam-trawl, the only apparatus by which it can be taken, is not used by our American fishermen, as it is by those of Europe. The mouth of this large flounder is so small that a hook small enough to be swallowed would not sustain the weight of the fish. There is every reason to expect that this fish will soon take its place in our markets. The Commission have also brought to light *new species* of food-fishes, i. e., of fishes supposed hitherto as only living in the colder waters of Greenland and Scandinavia. These, too, American enterprise will yet bring to our markets; but, to do so, fishing must be carried on two or it may be three hundred miles from the coast.

Improved Method of diving and staying under Water.—The apparatus now in use for supplying air to divers engaged in submarine operations is both cumbrous and unsafe, the air-tube limiting the movements of the diver, and, by its liability to become entangled and crushed, causing a risk that the supply of air for respiration may be cut off altogether. A new method, in which these drawbacks are escaped by dispensing entirely with the air-tube and pumps, has been invented by a Mr. Fleuss in England, and lately exhibited at the Royal Polytechnic Institute in London. Dr. B. W. Richardson was given an opportunity to closely watch its operation, and from his description in "Nature" we glean the following account of the experiments: The peculiarity of the method consists in the diver's taking a full supply of air-food down with him, which dispenses with pumping, no help being needed except a signal-man and cord. Mr. Fleuss is both inventor and diver. He descends into the water in an ordinary diver's dress. It consists of helmet, breastplate, and common water-tight armings and leggings. On his shoulders he carries a weight of ninety-six pounds, and on his boots twenty pounds. A light cord is attached to the helmet for signaling to the person above. Before the mask is closed and the helmet adjusted, an "ori-nasal mouthpiece," with

a breathing-tube of an inch bore proceeding downward, is firmly tied over the mouth and nose. Dr. Richardson carefully observed two experiments, one of twenty minutes' length, and another of an hour; and was assured by the diver that when under water he breathed as freely and easily as in the air. This was confirmed by his appearance and condition at the end of the longest experiment. He moved about on the floor of the tank, picked up coins, and could lie down and get up without difficulty. The exact mode by which breathing is effected Mr. Fleuss declares to be extremely simple, though it still remains a secret, but it is wholly carried on within the apparatus, not even the expired air becoming apparent in the water. The facts demonstrate that, without assistance from above, a man who has had no previous experience of diving or remaining under water can take down with him sufficient oxygen to live there easily for an hour; and but for the cold the diver asserted that he could have remained another hour and a quarter, and that he could easily arrange to remain four hours. Depth he said would make no difference as to breathing within the apparatus. Dr. Richardson is enthusiastic over the practical possibilities of the discovery. If a man can thus take his stock of breathing material with him, and live for hours without external access of air, he may extend the field of his industries and investigations into the deep sea, or the most rarefied atmospheres, into mines filled with choke-damp, or amid the suffocating smoke of conflagrations, without fear of consequences.

Suicide of the Scorpion.—The following facts, as stated by Mr. Allen Thomson in "Nature," throw some light on the mooted question of the self-destruction of scorpions. He states that while residing at Lucca, in Italy, he was greatly annoyed by the intrusion into the house of small black scorpions, which secreted themselves in bed-clothing and articles of dress. Having been informed by the natives that this animal would destroy itself if exposed to a sudden light, attempts were made to dispose of the pest in the manner suggested. When one was caught it was accordingly confined under an inverted glass until evening, when the light of a candle was brought near it. At this, the scorpion showed great excitement, rushing round the glass with reckless speed. This state lasted for a minute or two, when the animal suddenly became quiet, and turning his tail over its back brought the recurved sting down upon the middle of its head. Soon it became motionless, and in fact dead.

Electricity and Vegetation. — Several months ago M. Grandeau and M. Leclerc described to the Paris Academy experiments on the influence of electricity on vegetation. From these it appeared that flowering and fructification are retarded whenever plants are excluded from this agent. Recently M. Naudin has been examining the subject, repeating the experiments of Grandeau and Leclerc under different circumstances, and with widely different results. He regards the question as a complex one, and far from being yet settled. The influence of electricity on plants is probably modified by the species, by climate, season, temperature, dry or wet weather, degree of light; possibly, also, by the geological and mineralogical structure of the ground. Until we are better acquainted with these obscure conditions of the problem, any conclusion applied to the whole of the vegetable kingdom is premature.

Transmissibility of Human Rabies. — Whether hydrophobia can be transmitted from man to man, or from man to the lower animals, has long been a disputed question, with little scientific evidence on either side; some recent observations, however, by M. Raynaud, in the Lariboisière Hospital, in Paris, would seem sufficiently conclusive to put an end to all uncertainty on the subject. A man was brought to the hospital suffering from rabies, having been bitten by a dog on the lip forty days before. The wound was cauterized two hours after it was made, and no serious apprehensions were felt about the result until a few days before he entered the hospital, when the usual symptoms of hydrophobia appeared. The day before his death, in a quiet interval, he yielded with the best grace to experiments in inoculation which were made with his blood and his saliva. The result

of inoculating a rabbit with the blood was negative (as in the great majority of previous cases of inoculation with blood of animals under rabies). But with the saliva it was different. A rabbit inoculated in the ear and abdomen on the 11th of October began to show symptoms of rabies on the 15th, being much excited and damaging the walls of its cage, while it uttered loud cries and slavered at the mouth. Then it fell into collapse and died the following night. The rabbit's body was dissected thirty-six hours after death, and further experiment was made by taking fragments of the right and left submaxillary glands and introducing them under the skin of two other rabbits respectively. These two rapidly succumbed, one on the fifth, the other on the sixth day (becoming visibly ill on the third); neither passed through a furious stage, however, and the predominant feature was paralysis. The important practical result is, that human saliva, such as caused rabies in the rabbit, is necessarily virulent, and would probably have corresponding effects on man; so that it should be dealt with cautiously, and that not only during the life of the person furnishing it, but in *post-mortem* examinations.

The Agency of Plants in Earth-Building.—The important question of the part taken by plants in earth-building is discussed by Professor Ernst Hallier, of Jena, in a popular essay on "Plants and Man in their Interrelations." The contributions made by the vegetable world to the formation of the crust of the earth are most obviously shown in the beds of peat and coal, the remains of former immense forests and swamps. These formations, remarkable and important as they are, Professor Hallier observes, are far exceeded by the less apparent changes which are effected by the agency of plants. The deposits of fresh-water limestones are largely the results of plant-action. Nearly all the streams in calcareous regions bring down carbonate of lime in solution as a bicarbonate. Their waters being charged with carbonic acid or having absorbed it from the air, are by its aid enabled to act upon the otherwise insoluble carbonate of lime, and to take up a quantity of it proportioned to the amount of carbonic acid they contain. This dissolved lime is in its turn converted by the plants which grow in and under the water into stone. All the carbon that is needed for the organic world, animals as well as plants, is obtained through the action of plants in extracting carbonic acid from the air. Plants and those parts of plants which are under water do not stand in direct relations with atmospheric air, but are dependent on the carbonic acid which is held in the water, and, when this is exhausted, on the dissolved bicarbonate of lime. A part of the carbonic acid is taken up from this substance by the chlorophyl-cells, while the other part remains fixed in the lime in the form of simple carbonate of lime. Since the latter is insoluble in water, it is deposited just where it happens to be, which in this case is on the surface of the plant, and this becomes covered with a coating of limestone. Fresh supplies of water bring down new stores of carbonic acid and the dissolved bicarbonate of lime, and the plants continue their work of converting the latter into the insoluble carbonate. Thus the work goes on unceasingly, and crust on crust of limestone is deposited on millions of small plants. The plants themselves die, wholly incased in stone, but new ones succeed them, and the layers of petrified plants bear in continuous succession a green coating of growing plants. Strata are added to strata, and the limestones grow enormously through the quiet activity of the charæ, mosses, reeds, grasses, and other plants in the water. Fresh-water limestones are thus still in process of formation in all limestone regions. The minor valleys of the Thuringian Valley contain large bodies of soft, fresh-water limestones, in which the forms of the plants to whose action they are due may be plainly recognized, partly in incrustations, partly in impressions, mixed with fresh-water shells and with remains of the trees which once grew on the shore. The material, though soft, has been used in the manufacture of a building-stone out of which cities like Jena and many towns have been built. Rock-building of this kind has been going on ever since there was a growth of plants on the earth, and has during that time played a considerable part in forming the crust of the earth. Other far smaller plants

are occupied in building up rocks, in comparison with the work of which, the labor of the plants we have considered may be called insignificant. The diatoms, which live in fresh and salt waters, are the smallest of all organisms. They were once thought to be animals, but are now regarded as plants, and are one-celled structures which have the property of sucking up large quantities of carbonic acid from the water and storing it in their cell-walls. They increase by repeated divisions and subdivisions of their cells, and build up rocks by their simple presence. They multiply with such prodigious rapidity, and the number of their genera and species is so great, that under favorable conditions, as in the shallows and muddy flats of the seashores and in wet places in the interior, they contribute the substance of whole strata by leaving behind them when they die their silicated cell-walls, which become consolidated with the earthy materials into a harder or softer rock-formation. The magnitude of the operations of this kind that are going on in the present epoch is illustrated in the Lüneberg heath, where the diatomaceous formation is more than thirty feet thick. The city of Berlin is built upon a bed of clay of from six to one hundred feet thick, two thirds of the mass of which consist of diatoms. There is a puzzling feature in the life of these diatoms. They contain a coloring matter, *diatomin*, which is similar to chlorophyl in its properties and in having the power of abstracting carbonic acid from the air and water. It is hard to understand how this power can be exercised where the light does not penetrate. Yet a great mass of the diatom bed under Berlin is living and active, and streets and houses have been disturbed by its growth. The functions which the diatoms perform in the present history of the earth were also exercised by them during the earliest epochs of which we know, and probably in still earlier times.

Intelligence of a Pet Monkey.—A writer in "Chambers's Journal" vouches for the truth of the following story about a pet monkey, which, even if taken with many grains of allowance, exhibits a remarkable degree of intelligence that, in many respects, seems scarcely less than human: "Peter" belonged to an officer in the British Army, and was a large and powerful specimen of his class. He was a general favorite, his unusual sagacity and varied accomplishments forming a source of endless amusement, and, although somewhat mischievous, his gentleness of disposition and genuine love of fun readily secured forgiveness for occasional annoying pranks. Unfortunately, however, Peter had an enemy in the person of a diminutive and unpopular subaltern, to whom he appears, in some mysterious way, to have rendered himself particularly obnoxious. During a temporary absence of his master the monkey was intrusted to the care of a brother officer, who, being anxious that he should suffer no harm, chained him to a chest of drawers in his own room. This well-meant restraint did not coincide with Peter's desire for freedom, and, left to his own resources, he sought about for some means of diversion. Having first forced open the locks of all the drawers, he strewed their contents upon the floor, and seated himself in the midst, "monarch of all he surveyed." Next, discovering an inkstand within reach, he bedaubed with its contents every article belonging to his hospitable entertainer. When his host returned, Peter appeared totally unconscious of having been guilty of the slightest misdemeanor. He was not punished, but summarily dismissed from his comfortable quarters and allowed to wander freely about the barracks. All went well for a time, but, later in the course of one of his rambles, Peter unluckily encountered his enemy, and, springing upon the shoulder of the irate and alarmed subaltern in the presence of a large number of officers and men, he nearly succeeded in drawing the sword of his victim, who, according to report, was not at all likely to draw it himself. The ludicrous position of the latter, amid the loud laughter of the men, served only to increase the subaltern's hatred of the popular monkey. Shortly after this, Peter was fired at and seriously injured. Though it was impossible to prove who was guilty of this cowardly act, it was naturally attributed to the subaltern, who, it was well known, had never forgiven the indignity inflicted upon him in public. Peter's friends exerted themselves to save his life;

the slugs were extracted, and he was soon convalescent. At this juncture his master returned, and the joy of the monkey was unbounded. "He clung to him and fondly embraced him over and over again, repeatedly kissing or rather licking his face and hands, with every possible demonstration of the most devoted attachment." When the first paroxysm of delight was over, Peter clasped the arm of his friend to bespeak special attention, "pointed with his own forefinger to each of the wounds whence the slugs had been taken, trying at the same time, in the nearest approach to speech that he could accomplish, to tell the piteous story of his narrow escape from a violent death. . . . It is questionable if the most intellectual of human beings not gifted with the power of speech could have acted more pathetically, or indicated more vividly what had occurred to them during the absence of their natural protector and dearest friend."

Announcement of Astronomical Discoveries.—For the purpose of making astronomical discoveries known to the public, speedily and in a systematic manner, Lord Lindsay has devised a plan for international communication of such information, and sent circulars to the leading observatories, public and private, everywhere. He promises to distribute notices of discovery within twenty-four hours of the receipt of the telegram to those who favor him with their addresses. The following is the substance of his circular:

THE OBSERVATORY, DUN ECHT, ABERDEEN,
November 1, 1879.

SIR: I am very anxious to form some system whereby information of astronomical interest may be rapidly and widely disseminated among English observers, and I would beg to ask for your assistance in carrying out my plan. In the event of your discovering a comet, new star, or other object of immediate interest, I would ask you to send me a telegram announcing the discovery, and giving such details as are usual. I have purposely omitted to mention minor planet discoveries, inasmuch as this branch is already admirably carried out by the Berlin Observatory. For convenience, the telegram should be in the form recommended by the Vienna Academy in the seventy-fifth volume of the "Astronomische Nachrichten," No. 1785, page 143, as follows: Comet (new star, etc.), discoverer, date, local mean time of observation (in hours and minutes), place of discovery, right ascension in *arc* (degrees and minutes), north polar distance (degrees and minutes), daily motion in R. A. and N. P. D. (minutes of arc), plus or minus, description, diameter of comet, etc. (in minutes of arc).

Thus a telegram would run:

Comet Winnecke, 5 April, 1445. Strasburg, 3215707508. Motion 0, minus 60.

This would read:

Comet discovered by Winnecke, 5th of April, 14 hours 45 minutes mean time, Strasburg, R. A., 331° 57′, N. P. D., 75° 8′. Daily motion, stationary, R. A., minus 60′ in polar distance.

Naughts should be put in where there are no significant figures, so as to make three figures for degrees and two for minutes (five in all), in R. A. and in N. P. D.; similarly, four in the local time.

Telegrams, etc., should be addressed *Observatory, Dun Echt, Aberdeen.*

(Signed) LINDSAY,
President Royal Astronomical Society.

Arsenic in the Household and School.—When somebody is accused of having dosed a fellow mortal to death with arsenic, State authority and newspaper interest immediately vie with each other in their efforts for the protection of human life. Unfortunately, however, both are much less alive to other and far greater dangers arising from the reckless employment in the arts and manufactures, and the ignorant introduction into our households, of this same deadly poison. Its use in the preparation of pigments is very common, and the employment of these for coloring articles of attire and for the various styles of paperhangings is scarcely less so. Not only are those engaged in the manufacture of these coloring matters exposed to the deleterious influence of the poison, but far larger numbers ignorantly purchase and use the articles containing it, and in a way that makes its action but little less virulent than the direct administration of the pure drug. Instances of this are constantly recurring in medical practice. Socks colored with compounds containing arsenic have produced disease of the feet; boots lined with flannel colored with Scheele's green have caused the death of their wearers; bright maroon-colored flannel worn next the skin, paper collars, necktics, hat-linings, gloves, artificial flowers, and even ladies' dresses, have all been the cause of disease from the presence of this poison. Its use for coloring wall-papers, and especially the cheaper sorts, is almost universal; and, while the greens are probably the worst

of the lot, they are by no means the only ones containing arsenical pigments. A recent number of the "Lancet" gives an account of an aggravated case of poisoning, due to a red paper on the walls of a sitting-room; and arsenic has also been found in white, gray, blue, mauve, and brown wall-papers in abundance. As an instance of the utter disregard of consequences shown by manufacturers in the use of these pigments, we may cite the statement published by Miss Osborne, of the Sydney Hospital, New South Wales, that large quantities of poisonous pigments are consumed in that colony in coloring sweetmeats for children. We give in another place in this number a letter from a chemist in Pittsburg, showing an equally flagrant case of carelessness in the manufacture and use of arsenical papers for the operations of the kindergarten. People who thus disregard the welfare of their fellows, scattering poison broadcast in a way that neither age nor condition can escape, are, we submit, entitled to some small share of attention from the press, and from the courts.

Artificial Diamonds.—The "todo" about the artificial production of the diamond has been set at rest by Professor Maskelyne, who, in reply to numerous letters of inquiry on the subject, sends to "Nature" the results of his examination of the Macteor specimens which came into his hands for the purpose. He tested these so-called diamonds—1. With reference to their hardness; 2. Their refracting power; and, 3. Their combustibility. The samples sent to him were "too light to possess appreciable weight, too small even to see, unless by very good eyesight or with a lens," yet were sufficiently large to serve his purpose. "A few grains of the dust—for such the substance must be termed—were placed between a plate of topaz—a cleavage-face with its fine, natural polish—and a polished surface of sapphire, and the two surfaces were carefully 'worked' over each other with a view to the production of lines of abrasion from the particles between them. There was no abrasion. Ultimately the particles became bruised into a powder, but without scratching even the topaz. They were not diamond. Secondly, some particles more crystalline in appearance than the rest were mounted on a glass microscope slide and examined in the microscope with polarized light." They each and all presented powerfully the property of doubly refracting light. Finally, two of these microscopic particles were exposed to the intense heat of a table blowpipe on a bit of platinum-foil. They did not burn. They were afterward placed in contact with two little particles of diamond-dust, exceeding them in size, and the experiment, on being repeated, "showed that the diamond particles glowed and disappeared, while the little particles from Glasgow were as obstinate and as unacted on as before." When subjected to a stream of oxygen gas the result was the same. Hence, Professor Maskelyne concludes that the substance supposed to be artificially formed diamond *is not diamond* and *is not carbon*. Further experiments led him to the conclusion that it consisted of some crystallized silicate, or possibly of more than one such.

The fate of the Glasgow diamonds has induced Professor W. Mattieu Williams to send to "Nature" an account of his experience in diamond-making, for the benefit of those who may have an attack of the diamond mania. He states that for the popular class-room experiment of burning phosphorus in oxygen he used a cup of chalk, deeper and with a smaller rim than the brass cups usually made for this purpose — the object of this being to check too rapid outburst of combustion. He observed that a cup, several times used for this purpose, became coated on the inside with a hard, glassy enamel, which he supposed to be phosphate of lime. To test this, the cup was thrown into hydrochloric acid and dissolved, but at the bottom there remained a residue of insoluble crystalline particles. "Could it be possible that the carbonic acid, driven off by heating the chalk, had, in reaching the heated phosphorus, become dissociated, its oxygen combining with the phosphorus, and its carbon thrown down as veritable diamond?" These crystalline particles when tested were found to scratch a glass pestle and mortar in which they were rubbed, but were too small for further examination. To obtain a better supply, phosphorus was dissolved in bisulphide of

carbon, and this solution mixed with pounded chalk constituted a paste which was put into a porcelain crucible, and the mass fired by heating it over a Bunsen burner. "It blazed magnificently, throwing out eruptive jets of flame. Here, in the absence of surrounding oxygen, the carbonic acid had every opportunity of becoming dissociated or reduced by the heated phosphorus." The residue, treated with hydrochloric acid, yielded a quantity of crystalline grains. These, when tested, left scratches on the glass mortar and pestle, and even seemed to leave slight marks upon an agate pestle and mortar. Examined, however, under a microscope, they resembled pebbles more nearly than crystals, and this fact led to the theory that they were "miniature chalk-flints formed by the fusion and aggregation of the silicious cuticles of fossil diatoms." This was tested by precipitating pure carbonate of lime, soaking it with the phosphorus solution, and, after firing it, treating it with hydrochloric acid, when *all trace* of dissociated carbonic acid disappeared, and neither diamonds nor other crystalline residue remained.

A New Preservative Process.—Herr Wickerscheimer, preparator in the Zoötomical Museum of Berlin, has invented a process for preserving plants and the bodies of animals, which has appeared to be of such value that the Prussian Government has procured the patent, and given it to the public. The inventor describes the process in his specifications as follows: "I prepare a fluid with which I impregnate the object to be preserved in different ways, according to its nature or the purpose I have in view, or the manner in which I preserve it. The bodies of men and animals preserved by this process retain perfectly their form, color, and suppleness, so that we may take sections from them years afterward for the purposes of science or of criminal justice. Under its operation, corruption and the insalubrious odors produced thereby cease. The muscular tissue presents on cutting it a condition like that of a fresh body. Finished preparations of selected parts, as the ligaments, lungs, intestines, etc., preserve their softness and flexibility, and the hollow parts may be even blown out. The parts of bugs, crustaceans, and worms, remain movable without exception. The colors may be made to remain perfect if it is desired, in animal as well as in vegetable bodies. The preserving fluid is prepared as follows: In 3,000 grammes (46,500 grains) of boiling water dissolve 100 grammes (1,550 grains) of alum, 25 grammes (387 grains) of common salt, 12 grammes (186 grains) of saltpeter, 60 grammes (930 grains) of potash, and 10 grammes (155 grains) of arsenious acid. To ten quarts of the neutral colorless and odorless fluid add four quarts of glycerine and one quart of metylalcohol. The process of preservation, which is applicable to the dead bodies of men, dead animals, and vegetables, as well as to single parts of the same, consists, to speak generally, in soaking them and impregnating them with this mixture. If the preparations are to be preserved dry, they are kept in the fluid for from six to twelve days, according to their size, then taken out and dried in the air. The ligaments of skeletons, the muscles, crustaceans, bugs, etc., will then remain soft and pliable, so that all the natural movements can be produced on them at any time. Hollow organs, as the lungs, intestines, etc., are filled with the fluid before being put into it. After taking them out and pouring out the fluid from the inside, they are dried, and should then be blown out. If it is desired to preserve smaller animals, like lizards and frogs, and vegetables, with their colors unchanged, they should not be dried, but should be kept in the fluid. If bodies of men or beasts are to lie for a considerable time before being used for scientific purposes, it is enough to infect them with the preservative fluid. For this purpose, I apply, according to the size of the object, one and a half litre (about three pints) of the fluid for a child of two years, five litres (or quarts) for a grown person. The muscles will appear then, even after the lapse of years, fresh when cut. If the infected bodies are kept in the air, they will lose their fresh appearance, and the epidermis will become somewhat brown; but that may be avoided if the body is rubbed on the outside with the fluid, and is then kept shut up in an air-tight case. The last method is recommended in the case of corpses which

are to be kept for some time before they are buried; instead of having the usual stiff look, the features and color will seem fresh and unchanged, and the bodies will not have a trace of odor. For embalming, I infect the corpse first, then put it into the fluid, and, after keeping it there for a few days, rub it and dry it, wrap it up in a cloth moistened with the preserving fluid, and keep it in an air-tight case. The treatment in different cases is governed by circumstances, but the composition of the preserving fluid is always the same."

Applications for Phylloxera.—M. Mouillefert, of the École Nationale d'Agriculture of Grignon, reported to the Academy of Sciences, Paris, November 10th, the results which had been obtained from the treatment of vines affected by the phylloxera with sulpho-carbonate of potassa. The efficacy of the salt appeared to be certain when it was applied with water according to the rules approved by the commission of the Academy. Vines that were very much weakened had been regenerated after such treatment, became free from spots, and bore fruit as they had done before they were attacked. The importance of water as the vehicle with which the remedy should be applied was strongly insisted upon. The sulpho-carbonate may be applied in all weathers and in all seasons, even in the cold months, without any danger to the vines; up to a certain dose (eighteen to twenty-five ounces to the square yard), the remedial effects are in nearly a direct proportion to the amount of the salt applied. At a subsequent meeting of the same body, December 1st, M. Frémy disputed the value of the sulphuret of carbon as a remedy for the phylloxera, and asked several questions of M. Thénard, who has recommended the application of that substance, as follows: 1. We know that sulphuret of carbon kills the phylloxera, but it also kills the vines; can we find a certain way of securing the former result while we avoid the latter? 2. Can sulphuret of carbon be easily and practically applied without affecting the health of the vine-dressers? 3. It is alleged that, by sacrificing one third of the vines, we can save the other two thirds; is this true? 4. Has the invasion of the phylloxera been arrested anywhere by the employment of sulphuret of carbon? Even if we are pointed to an apparent instance of the fact, we shall have to accept it with reserve; for cases are known in which vines which have not been treated still remain healthy in the midst of contaminated vineyards. M. Thénard failed to give a precise reply to the questions, which indicate very clearly the qualities that are required in a safe and efficacious remedy for the disease.

Parkes on Tobacco-Smoking.—We give below a very interesting and instructive letter written by the late Dr. Parkes, a short time before his death, in reply to a request for his views on the subject of tobacco-smoking, and recently published in the "Lancet":

MY DEAR DR. PRATT: I think my state of mind as regards tobacco is very much what yours seems to be. I have honestly tried to collect evidence from *moderate* smokers, both medical men and others, and, when tolerance has been established, I have never been able to make out any symptoms which implied injury. In the case of many medical men whom I have asked to study their own condition, the answer has always been the same—viz., they could see no harm or disturbance of any function. Even in some cases of enormous smokers—i. e., men who rarely were without a pipe or cigar—I could learn of no injury. On the other hand, I have seen, like all of us, men complaining of dyspepsia, nervousness, palpitation, etc., and who were much better for leaving off smoking; in fact, in these cases there could be no doubt of an injurious effect. In boys of fourteen or fifteen who begin to smoke, I think I have observed that tolerance is slowly attained, that appetite is less, and I presume digestion and nutrition less good, and that the complexion becomes pasty and less florid and clear. There was a striking case of this kind in the son of a medical friend, who watched his son naturally very carefully, and who told me that the effect of the tobacco (a good deal was smoked) was quite unmistakable. I persuaded the son to lessen his tobacco one half, and his health certainly improved, but he was then a young man. That some injury, therefore, is sometimes produced, and

especially on young people, seems to me quite clear; but it is curious, in other cases, how difficult it is to find ill effects, even in the young, when the quantity is not excessive. As to the effect on the young even, it is curious in Burmah to see children smoking in their mothers' arms; and yet when I was serving in Burmah, many years ago, I often saw a woman walking along smoking her cigar of tobacco rolled up in a plantain-leaf, and carrying on her hip her child of two or three years old, who also had his or her little cigar, which was smoked with the greatest gravity. On talking to the Burmese (who smoke constantly), they would never allow that even young children were in the least damaged. When I was in Turkey I tried to make inquiries of some of the intelligent Turkish gentlemen; one or two of them said that they thought the Turks had learned to smoke from the Europeans, and had been growing apathetic and dull ever since. But others laughed at this, and the rural Turk, who smokes a good deal, is a fine, active, energetic fellow. I have talked to many Germans, who all stand out manfully for tobacco. In conclusion, I confess myself quite uncertain. I can find nothing like good evidence in books; too often a foregone conclusion, without any evidence to back it, is given. I think we must decidedly admit injury from excess; from moderate use I can see no harm, except it may be in youth. My opinions are, you will see, very indefinite, and I would gladly see some really good evidence collected. If at any time you can send me any facts, I shall be very grateful.

Believe me, very sincerely yours,

E. A. Parkes.

Bitterne, Southampton, *January* 28, 1876.

Intoxicating Properties of the Hemp-Plant.—Mohammedans, Hindoos, and others, whose religion forbids them the use of alcohol, find in this plant a substitute which, though not so pleasant to the taste, is on the whole far less injurious in its habitual use. It is taken in various ways. Mixed with tobacco, it is smoked in the hookah, and, to those unaccustomed to it, smells abominably. It is also taken in decoction, and in a solid form in sweetmeats. In ordinary doses it acts as a gentle and pleasant stimulant, exciting none of the brutal coarseness produced by alcoholic excess. In larger quantities it appears to banish all sense of fear, and is often taken by the Indian sepoy before entering into action; and Mohammedan fanatics brave death under its influence. On account of this property, the Afghans are reported to have used it freely in their recent war with the English, many of the fierce onslaughts made by small parties of natives on the foreign soldiery being traceable to its effects. When taken in excessive quantities it produces a form of madness, characterized by a reckless passion to destroy every living thing that comes in the maniac's way. It is related of an English officer at Delhi that, desiring to try the effects of hemp on himself, he inadvertently took an overdose, and bareheaded, on a scorching day in May, rushed down the road, armed with a large knife, and fiercely attacked a bullock, which was the first thing he met. He was quickly secured and disarmed, and, under the care of the doctor, who shaved his head and applied ice, was soon brought to his senses again.

Common Sense in Emergencies.—The story is told of Brunel, the eminent engineer and builder of the Thames Tunnel, that one day, while amusing a child with tricks of sleight-of-hand, he attempted one which resulted in a serious accident to himself, and at the same time illustrated the danger of playing pranks with the mouth. The trick consisted in adroitly concealing a half sovereign in his mouth and pretending to bring it out at his ear. All at once to his dismay the coin slipped down into his gullet, and there stuck in spite of every effort, surgical or otherwise, to dislodge it. In this dilemma common sense came to the rescue. Brunel himself devised an apparatus to which he was strapped head downward, keeping his mouth open, when, to his inexpressible relief, the coin dropped from its dangerous position and rolled out upon the floor. A sword-swallower, who once lost a bayonet in his throat during one of his public performances, resorted to similar means for recovering it, and was equally successful.

Passivity of Iron.—It has been observed that iron which has been treated with concentrated nitric acid assumes a passive state and refuses to be acted upon by the com-

mon or diluted acid, but the cause of the property has not hitherto been satisfactorily explained. M. Louis Varenne reported recently to the French Academy of Sciences that he had remarked that passivity was destroyed and the metal could be made to yield to the solvent action after a shock or jar was given to it, or a current of carbonic acid or hydrogen gas was passed over it. He was led to believe that an envelope of gas was formed around the metal which protected it, and, on examining some passive iron, found that it was actually covered with a layer of gas. The metal was then placed in a receiver and a vacuum was produced, with care not to touch the iron or disturb it in any way, after which it was plunged into the diluted acid, when it was readily attacked. The nature of the protecting gas was ascertained by introducing a little air into the exhausted receiver, when the orange color characteristic of the nitrous vapors was observed. The gaseous sheath is, therefore, chiefly composed of the deutoxide of nitrogen.

NOTES.

THE Berlin Geographical Society recently celebrated the birthday anniversary of Carl Ritter, the famous German geographer. He founded the society in 1828, and presided over it until 1860. The university, the army, and various German societies, were largely represented, and handsome subscriptions were announced for a memorial to the hero of the evening.

THE death is announced, on the 19th of December last, of Francis Boll, Professor of Comparative Physiology in the University of Rome. Though young, Professor Boll had contributed effectively to the advance of medical science by his physiological researches.

IT has been a mooted question among physiologists whether saliva is destroyed in the gastric juice, or whether it continues its activity upon starch in the stomach. Recent researches by M. Defresne seem to prove that saliva is rendered entirely inactive in pure gastric juice; but that in gastric juice combined only with organic acids the conversion of starch into sugar proceeds as in the mouth.

IT is announced that Leibnitz's calculating machine has been found. During his stay in Paris, in 1672, Leibnitz invented and constructed this machine, which was the wonder of the time. It can add, subtract, multiply, and divide. It early became the property of the Hanover Public Library, but long since disappeared from its treasures. Nothing was known of its whereabouts, except that it had been sent to an instrument-maker at Göttingen to be repaired. Through the efforts of Dr. Bodemann it has again come into the possession of the Public Library at Hanover.

THE "Pall Mall Gazette" is authority for the statement that California whalers returning to San Francisco report the death by starvation of large numbers of Esquimaux in the vicinity of Behring's Strait. This is ascribed to the scarcity of walrus-meat, caused by the indiscriminate destruction of these animals by American whalemen—as many as a hundred thousand a year, it is said, having been killed by them.

MR. BILLIN, in a paper on the preservation of timber, read lately before the Engineers' Club of Philadelphia, stated that creosoted ties in use for twenty and twenty-two years in England were still in as good a state of preservation as when first laid down. Creosoted piles driven at Portsmouth, England, forty-two years ago, were now as good above as below the water-line, and have outlasted sixteen sets cut from the same timber, and driven in the same work, but which were not creosoted.

M. J. BERNÁTH writes to "Nature" that our knowledge of the mineral waters of Hungary is altogether fragmentary and imperfect in kind. In the interest of truth he points out that a work, bearing the title "Les Eaux Minérales de la Hongrie," published under the auspices of the Hungarian Commission of the last Paris Exhibition, is altogether unreliable, and, in support of this opinion, states that the book enumerates less than forty per cent. of the localities in Hungary at which mineral springs occur; and, of the analyses published in the book, only those made twenty or thirty years ago find a place, the more recent and valuable ones being entirely omitted.

JOHN MEARS, F. R. S., whose botanical researches in South America, begun over fifty years ago, gave him a distinguished place among the botanists of England, died in London, October 17, 1879, aged ninety-one years. In 1825 he published "Travels in Chili and La Plata," and in later years contributed many interesting and valuable botanical papers to the "Transactions of the Linnæan Society." He bequeathed his herbarium of South American plants, numbering over 20,000 sheets, original drawings and manuscripts of his published works, and also some unpublished manuscripts, to the British Museum.

CHARLES F. CHANDLER.